SCIENCE REDISCOVERS GOD

"Reason cannot be so depressed by the doubts of subtle and abstract speculation as not to be roused from the indecision of all melancholy reflection, as from a dream, by one glance at the wonders of Nature and the majesty of the universe." . . .

—KANT

"When we consider what religion is for mankind, and what science is, it is no exaggeration to say that the future course of history depends upon the decision of this generation as to the relations between them." . . . .

—WHITEHEAD

SCIENCE REDISCOVERS GOD

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THIS BOOK IS DEDICATED TO

COMMON SENSE

*which many philosophers, professional and amateur, primeval,
ancient, medieval, and modern, say does not exist; yet which
has shown man how to predict an eclipse, to control
disease, to lessen suffering, to give some direction
to the forces of Nature, to use her substances,
and in general to lift himself to a more
dignified position in the universe*

Thou who didst inspire that Shepherd,
Who first taught the chosen seed,
In the beginning how the heav'ns
And earth rose out of Chaos;
Instruct me. . . . What in me is dark,
Illumine; what is low, raise and support;
That to the height of this great argument,
I may assert Eternal Providence,
And justify the ways of God to Men.

Preface

I AM a layman who is aware that, in a great many matters, scientific advice is invaluable. There is a distinction, however, between scientific advice and the advice of scientists. Scientific advice is unprejudiced and wide-visioned. Today, upon many of the most important questions, the advice of scientists is definitely biased and narrow-minded.

It is not my chief purpose to demonstrate in definite ways the almost unbelievable sway of false opinion among scientists or their remarkable shallowness of thought along a variety of lines. It is to demonstrate to scientists, to the religious, and to laymen in general that, beyond any doubt, there *is* a simple, logical, and scientific approach to religion.

Strangely, "it is an old story, but it remains always new." * The idea of anthropocentrism, that man is the center of interest of the cosmos, is ancient. Has it been carefully re-examined in the light of the recent discoveries of science? It has not. For one thing, it is too

* Heinrich Heine:

Es ist eine alte Geschichte,
Doch bleibt sie immer neu.

gigantic an undertaking for a specialist, who says he has no time to get a good grasp of any field besides his own immediate choice. In their most inclusive meanings, astronomy, geology, chemistry, physics, biology, and psychology are all definitely concerned. Though man may not be at the geometric center of the universe, may he not be the central figure in a stupendous cosmic pattern woven out of all the properties and activities of all forms of matter and all types of energy? Who but a layman would dare absorb himself in such a problem, when a present day scientist, in order to be considered a scientist by his colleagues, must not only remain buried in his specialty but also subscribe to the scientific creeds of the times?

Yet, is it not a philosopher's problem? Of course it is—if we want to be two thousand years behind the times and accept the oldest meaning of the name, philosopher. To be a philosopher in these days, you must obey academic rules of standardization and—weirdly—of specialization. You must keep your college position in order to live and to be able to continue philosophizing. To keep your college position you must continue to publish highly specialized bits of criticism concerning Kantian epistemology or concerning the relationship of pragmatism to the practical absolute. The professional philosopher cannot waste time on old-fashioned judgments because he has to maintain his reputation by floating with the fashionable trend and observing the philosophical taboos of the present; because he is too busy assimilating the daily discoveries of science so that he might fit them into set schemes; and because he is too befogged by dialectical doubts as to whether or not his thoughts are real, his toe is real, the chair against which he stubs his toe is real, or the pain is real.

American Philosophy. Today and Tomorrow is a 1935 symposium of twenty-five American philosophers. No two agree on anything of importance—unless it be that the public should be repeatedly informed regarding the complete uncertainty of everything in the universe, the transitory nature and basic elusiveness of all creation, and the entire disagreement of philosophers concerning all other things. Have these twenty-five forgotten that a man named Heraclitus, twenty centuries ago, said much more strikingly and interestingly than they, that: "All things flow, nothing remains"? If they are in complete accord with him, why take 518 pages to say so? By 1946 the same twenty-five will be writing thousands of pages on their re-discovery of Parmenides who stated: "Nothing flows, all things remain."

What of the theologian? We all know that he is a man at bay—abashed before science, pretending not to be, and admittedly abashed before the attempts of his pseudo-friends to reconcile science and religion. *Religion and Science* is Bertrand Russell's contribution to the subject as it stands at the beginning of 1936. By relentless logic, simple and clear, all the arguments of the most famous reconcilers are by him reduced to baseless opinion. I think that the sincere and broad-minded theologian would be the first to admit that, if he does not fall back upon mysticism and if he does not find himself able to go beyond the science and philosophy of today, he is at a total loss to point out any simple and compellingly logical approach to religion. And a man at bay would not seem to have ten years to spend in a re-examination of a discarded idea.

I have often been told that I cannot speak with authority because I have no academic position. I can find no place for myself in the card-catalog of modern scientists, philosophers, and theologians. I definitely belong behind the index-card labeled "Fools"—for I, a mere layman, make bold to challenge the assertions of the foremost thinkers. But, perhaps my challenge is not entirely that of a fool. I have for fourteen years sought, and sincerely and zealously sought, as solid a faith as my faith in the reality of that quite solid stone which

PREFACE

Dr. Johnson, according to Boswell, kicked by way of refuting the fantastic preciousness of metaphysicians. And as my readings and thoughts have attempted to travel every realm of science and philosophy, and as my notes have run into tens of thousands of pages and into millions of words, I think that you will find no error of fact or logic for which I should later have to apologize.

B. M. N.

Contents

CHAPTER I

Has Science Rediscovered God?

"NEWTON has spoken of God in his book," said Napoleon. "I have already gone through yours, and I have not found that name in it a single time."

To this Laplace replied: "First Citizen Consul, I have not had need of that hypothesis."

This anecdote of the First Consul and the astronomer's *Exposition of the World System* has deep meaning for the student of the millenium-enduring conflict between religion and science. Its background includes the wonder which came into being with Dawn Man; the practical and the priestly wisdom arising with civilization out of the mud of the Euphrates, the Tigris, and the Nile; the abstract reasonings of Thales, Pythagoras, and Aristotle; the teachings of the Prophets; the dogma of Christian theology; the logic of the metaphysicians from Paracelsus to Kant; the full-bodied facts of experiment and observation; the opinions of bishops, pagans, scientists, and laymen during hundreds of years.

Science once knew of God, discovering Him everywhere in the heavens and the firmament. There came a time when that Hypothesis was by the majority of nature-probers considered to be no longer needed: the heavens declare the glory of Chance, and the firmament shows the handiwork of Accident. Briefly, such are the thoughts which crystallized into the anecdote.

This thought-crystal is usually described without any mention of how Laplace himself regarded it in his later years. He felt that it was misleading. He was not expressing atheism but merely his ability to explain the development of the solar system upon purely mechanical principles. Indeed, the last words of the astronomer were: "What we know is little enough, what we don't know is immense."

Nevertheless, is the view of Laplace or the modern scientist anything more or less than agnosticism? Science in former days found evidence of God in the universe, but nowadays simply has nothing to say upon the subject. Of course it is true that certain scientists are mystics. But it is also true that there are as many forms of mysticism as there are mystics, and that mystical sensations can arise from contemplation of one's navel and not only from pondering the realities of science. Common sense looks upon scientific mysticism as an unintelligible paradox, and may with good reason inquire of the vision-struck man of research: "For all you can prove to me in your eminently clear, scientific fashion, may not your religious states be hallucinations induced by wishful thinking? Can you give me no evidence of God as tangible as your prediction of an eclipse?"

Einstein, in his *Cosmic Religion*, tells us that whosoever honestly and wholeheartedly accepts the assumption of causality finds it impossible to accept the idea of a Being who interferes with the sequence of events in the world. But the relativist believes in the reality of a mystical "cosmic religious sense" which "is hard to make clear to those who do not experience it." He thinks that something of this cosmic religious sense is to be found in the Psalms of David, in the Prophets, and much more strongly in Buddhism. The stimulus for this sense is "the nobility and marvelous order which are revealed in Nature and in the world of thought."

But is there really anything tangible in this scarcely-to-be-communicated feeling? If there is,—well, is not some Being interfering with the natural sequence of the scientist's thought processes? The star-sown night sky is, beyond all things, awful. In it our poetic side sees the signature of a Power ineffable. Yet in it our scientific side can see merely the cause of a weird sensation—according to the prevalent psychological opinion.

Sir J. Arthur Thomson, the biologist, is also a mystic.

To those who feel no necessity for religion and who "distrust as an anachronism the feeling of mystery that remains after the scientific concepts have formulated all they can," he says: "You have no sense of the mystical, just as others have no ear for music." He also states: "Science has given man a new heaven and a new earth, and in this he continues to strain at the limit of his intellectual effort and often finds no peace except that which literally passeth understanding—a belief in God." So, after science has had its entire say, we have heard no word of God. Then, out of the void of our ignorance, a Voice speaks to us: "There is a God—the One of the Shorter Catechism—a Spirit, Infinite, Eternal, and Unchangeable in His Being, Wisdom, Power, Holiness, Justice, Goodness, and Truth."

"The God of science is the Spirit of rational order, and of orderly development," according to the physicist, Millikan, in his *Evolution in Science and Religion.* Yet he too finds no direct evidence of God in the world of science, instead mystically and intuitively conceiving of God and of the necessity of accepting the teachings of Christ. He is sure that the order of Nature as revealed by science, the evolution of man from lower forms, the progress of science, and the opportunity for future progress, must inspire in every one a vision of an infinite, beneficent, personal Creator. Strangely, he tells us that when he stands in the halls of Physics he feels one with Darwin: "No man can stand in the tropic forests without feeling that they are temples filled with the various productions of the God of nature, and that there is more in man than the breath of his body." Millikan is evidently unaware how Darwin later described the waning of his religious intuition: "Now the grandest scenes would not cause any such convictions in me." A scientist should be the first to realize the danger of basing judgment upon emotion. Darwin himself warned against it.

Professor Henry Norris Russell, the astronomer, is paradoxically both a mechanist and a mystic. He accepts mechanism as a working hypothesis and assumes that "the solution of some vast equation would tell the whole story," even of the brain states of man. What *is*, was written in the beginning—all happenings have been predetermined: "Nor all your tears wash out a word of it." As for his mysticism: Assuming science can only describe the universe and can only answer the question *How?*, he states: "Though we knew but the order of Nature alone, we should have that which compelled reverence and commanded loyalty." When asked *Why the world?*, he replies that when we observe the general appearance of the world, our judgment-of-value (mystically) creates within us a firm belief in a divinely just, bountiful, Christian God. Why is there so much mischief among men? "The ways of God are past finding out." And the recognition of Divine justice in the world and especially of God's bountifulness compels man to have faith in immortality.

These views of Russell are, however, outside of the realm of science and are not facts but emotional opinions. Dante's Tantalus has appeared in human flesh many times on earth: would his intuitive views coincide with Russell's—though they both pondered the same sets of facts concerning the best of all possible creations?

To Sir James Jeans "the universe begins to look more like a great thought than like a great machine." But the astrophysicist cannot tell us what a thought is.

J. S. Haldane thinks that the living thing cannot be machine-like because it is so complex. Therefore, since it is not a machine, the laws of physics and chemistry break down when we come to biology and psychology. Physical chemistry is one level of understanding and biology is another. Psychology "constitutes a higher plane of interpretation, nearer to reality than mere physical or biological explanation." What is Reality? A personal God—the Christian God. WHY? Inner revelation—that is all. (I think it would be well if those who argue for religion along this line—that is, who use the so-called "argument of the various levels of interpretation"—it would be well if they thoroughly understood that the whole argument ultimately depends upon an inner revelation and a mysterious judgment-of-value, both of which really must be admitted to differ decidedly from man to man.)

Sir Arthur Eddington instinctively (i. e., emotionally or mystically) feels God and mind are more directly known than even physical phenomena. To the query, "What says science of God?," his reply is: "The fact that scientific method seems to reduce God to something like an ethical code may throw some light on the nature [shortcomings] of scientific method; I doubt if it throws much light on the nature of God."

Samuel Alexander's criticism of Eddington applies to all these embodied hybrid paradoxes, the scientist-mystics: "In the beautiful Quaker fashion, he trusts to the witness of God in ourselves and the light of Nature. But what guarantee have we that that light may not be a wandering fire?"

Alexander himself has a mystic feeling that God has not yet arrived. That is, knowledge of the evolution of man from lower creatures stimulates in Alexander an exciting interpretation of organic progress: Divinity is to emerge from the animal, man. Perhaps this interpretation is a true one, but we have no guarantee of the coming miracle. Alexander also finds evidence of God in the vague sense of mystery stirred up in most human beings by the contemplation of the grandeur of the cosmos.

C. Lloyd Morgan, who has made the term "Emergent Evolution" familiar, owes much to Alexander, but pictures evolution as starting from God. It is widely recognized at last that Morgan has not done any explaining, but is rather a word-coiner and a re-describer.

The late great paleontologist, Henry Fairfield Osborn, thought that materialism and pure mechanism give an interpretation of evolution which fails to satisfy the reason. He wrote:

"If the thought of the impotence of human reason impresses the physicists, it impresses biologists still more cogently. Many biologists have entirely abandoned mechanistic theories of adaptation and have frankly revived the old purposive interpretation of Nature, in the guise of vitalism, or *élan vital*. I do not belong to any of these schools, but if I have made a single contribution to biology which I feel confident is permanent, it is the profession that Democritus was wrong in raising the hypothesis of fortuity, and that Aristotle was right in claiming that the order of living things as we know them precludes fortuity and demonstrates purpose.

"This purpose pervades all Nature, from nebula to man. Herbert Spencer may call it the Unknowable; the naturalist, with Wordsworth, may call it the Wisdom and Spirit of the Universe." *

The opinion of Osborn, however, springs, in mystic fashion, from his own peculiar visualization of the universal scene, even as with his fellow-spirit, the more poetic Wordsworth, whom he quotes:

"Wisdom and Spirit of the Universe!
Thou Soul, thou art the Eternity of thought,
And givest to forms and images a breath
And everlasting motion!"

Because those scientists who are religious men have thus far adduced nothing scientific and nothing tangible in favor of the existence of Deity, however He may be defined, the man of common sense is on the side of the many present-day scientists who follow Laplace, Darwin, and Huxley in being agnostics.

Vernon Kellogg, the late zoölogist, was one of these numerous agnostic scientists. "The biologist," he said, "is a homely and practical-minded person who is little given to over-refined logic and debate but much given to observation and experiment." Further: "The man who makes the world all mental may have reached a higher kind of Reality than the biologist, but the biologist, as far as I know him, is not going yet, for the sake

* H. F. Osborn, *Evolution and Religion in Education*. By permission of Charles Scribner's Sons, publishers.

of ascending to this higher plane, to give up remembering what happens to the man who doesn't step off the railroad track and attempts to stop a mental-train by a mental-will, nor will he give up keeping his muscles in trim for a quick jump." Finally, "the biologist who is not a bigot cannot authoritatively and hence will not try to affirm that there cannot be human immortality. He simply remains agnostic. He does not know."

And so, Bertrand Russell, in his very recent work, *Religion and Science*, ably and incontrovertibly gives the sole honest judgment of man as at last portrayed in the light of the last four hundred years of the conflict between science and religion:

> "Man, as a curious accident in a backwater, is intelligible: his mixture of virtues and vices is such as might be expected to result from a fortuitous origin. But only abysmal self-complacency can see in Man a reason which Omniscience would consider adequate as a motive for the Creator."

The physicist, Arthur H. Compton, in *The Freedom of Man* has summed up his views on the subject as it stands at the beginning of 1936. Everything he says has been said many times before, and although his volume follows Bertrand Russell's latest, nevertheless *Religion and Science* has spiked all of Dr. Compton's guns even before their arrival on the scene of battle. Compton's opinion is that "the hypothesis of God gives a more reasonable interpretation of the world than any other." And for him, God is intelligent, sympathetic, and good. Immortality is a possibility. His evidence for these conclusions is neither new nor tangible.

The psychologist, William McDougall, offers as his stimulus to renewed debate, *Religion and the Sciences of Life*. Like so many other scientists, he stresses the limitations of physical science and also seeks uncertain refuge in the vagueness of intuition. Like Compton, he attacks and apparently totally demolishes the machine-world. Man as a mechanism is inconceivable to him. Furthermore, Dr. McDougall is convinced that the future of religion depends upon successful research, with positive findings, in the field of parapsychology or spiritualism: "Unless psychological research can discover facts incompatible with materialism, materialism will continue to spread" and revealed religion will vanish before "the destroying tide."

I think that many close observers of the religion-science imbroglio will agree with McDougall that the rise of materialistic science does have its definitely baneful effect upon religion, at least so far as thoughtful persons are concerned, i. e., those who cling to the precept "seeing is believing" and want to find some tangible evidence of God in Nature and thus a simple, logical approach to religion. But are discoveries in parapsychology the only way out? Has not McDougall forgotten that even mechanistic science can lead along another path and to first-rate proof of the presence of Divine Intelligence behind all things?

There have been, from the time of its first development, difficulties in connection with Heisenberg's principle of indeterminacy. Suppose that strict causality and an iron-clad mechanistic explanation of the cosmos should both be re-established, even as Einstein desires (*Nature,* March 26, 1927):

"It is only in the quantum theory that Newton's differential method becomes inadequate, and indeed strict Causality fails us. But the last word has not yet been said. May the spirit of Newton's method give us the power to restore unison between physical reality and the profoundest characteristic of Newton's teaching—strict Causality."

And suppose that physicists, Compton, Eddington, and Jeans included, and philosophers, Bertrand Russell included, should realize that, after all, there is no such thing as Chance—which little word slips so easily from the tongue of the thoughtless scientist and philosopher. Chance has ever been but another name for Ignorance.*

* See Chapter V.

(If you know all the factors involved, you can predict whether your penny is going to come *heads* or going to come *tails.*) Then, what of Man? Would he then be "an accident in a backwater"?

In other words, McDougall and many other scientists —perhaps all scientists—have forgotten that a mechanistic universe in which the law of causality strictly holds can still be proven a purposive universe. There are some who are convinced that the last word has not been said for teleology in Nature. Perhaps it may ultimately be shown that all cosmic forces have been intent upon the production of that little, hopeful creature, over-despised of science—Man.

I, for one, feel sure that when the stupendous total of factors involved in the creation, endurance, and development of that true miracle of organization—the human being—is more fully realized, then we shall be aware that he dwells beyond the realm of fortuity.

Still, we must all admit that as the combat now rages, the best that science or religion can prove concerning man is, in the words of Eddington:

"Nature seems to have been intent on a vast scheme of evolution of fiery globes, an epic in milliards of years. As for Man—that was an unfortunate incident which it seems rather ungenerous to refer to. It was only a trifling hitch in the machinery—not of very serious consequence to the universe."

CHAPTER II

Fifty Thousand Scientists can be Wrong

AT an outside estimate, let us say, there are in the world 50,000 scientists of every variety who are sufficiently well-trained, experienced, and deep-thinking to have opinions worth hearing. I mean opinions having to do with the general field of science—I would say having to do with the philosophy of science but for the fact that to the scientists, philosophy, which should be the acme of science, is the most airy-fairy speculation, and in its present state probably justly judged so. At any rate, we have our 50,000 capable scientists, apparently excellently fitted to pass upon questions of broad scientific import, and we are going to take an imaginary poll of them. We shall, in fancy, mail to each one of them a card bearing the following question:

> There is an idea, as ancient as the hills, that man is the chief concern of the universe. Do you think that this idea, re-examined in the light of the newer findings of science, could be logically and scientifically proven true?
>
> (Please answer YES or NO.)

Having indicated the return address, and having, in this frugal age, provided return postage, what would be the result of our poll? The number of returns would depend upon several factors, including the amount and kind of advertising which the project previously had, the characteristics of the envelope enclosing the card, the appearance of the card, the nature of the return address, and the general state of the world at the time the card was received. The tabulation of the replies would be the easier for the fact that only one of the two possible answers would come in to us: a distinct, forceful, and unanimous "No." Any one at all familiar with the conclusions of modern science as they are expressed in writings and lectures, technical or popular, must agree that this negative would be unanimous. If you do not believe me, essay my assay. Or query your scientist friends.

The flippant have we always with us. Hence, a certain small percentage of our homing cards would reappear inscribed "Who cares?," and another small proportion inscribed "Why bother?" Finally, if we have ever listened to an expert trying to make up his mind, especially upon a problem somewhat novel to him, we are in a position to believe quite readily that there would be a third group indecisively marked "Yes or No."

Before proceeding to comment upon the returns, I cannot help interjecting that I think I have been monstrously flattering in assuming that there are 50,000 scientists whose broad opinions are worth hearing. That is, by far the great majority of scientists are so narrowly specialized—almost unbelievably so—that their ideas on subjects anywhere outside their own immediate line are so unsupported by fact as to be no more valuable than the views of a male nurse concerning the larger conceptions of biology. (I would like to be fair to the male nurse. Perhaps he is just that because he finds in this profession of his all the time he needs for reading up on the relationship of man to the cosmos at large. But be there such a man, he is precisely the one I would like most to meet.) Does a fifty-year study of inheritance in the banana fly entitle a man to evaluate the data of earth-chemistry and their relation to the problem of a man-centered universe? Is the astrophysicist so familiar with the nature of the extreme delicacy of protoplasm that he can command attention when he states that the lower forms of life may well exist on Mars? Can the chemist give good reasons for the universal assumption among his colleagues that the architecture of the elements is only incidental to earth-begotten organisms? Is the biochemist to be hearkened unto when he answers the question: Are the fitnesses of energy for the existence of life so peculiar and unique that we must be convinced that the world of energy is biocentric, as some think the world of matter? In other words, simply because a man has spent his life determining the average volume of a variety of Amoeba proteus, is he entitled to broadcast that the human race is of no more moment to the magnificence of creation than a certain parasitical species that dwelt in the digits of Eohippus, the dawn-horse, dead these millions of years?

I have interjected a criticism, and to those who are aware of the immensity of knowledge that is science, it may seem more than slightly unfair. Yet what I have said or insinuated is true. Thus far, it is destructive criticism, which is in itself valuable at times, if only to point out sources of error. Later on, in the appropriate connection—for this interjection has been no passing whim—I can offer constructive criticism, which can be taken for what it is worth. But now the returns from our poll are awaiting comment.

The unanimity of opinion is noteworthy. This smacks more of the cocksure than of rational judgment, and for the following reason: no one fit to undertake the labor has in recent times attempted the colossal task of scientifically re-examining this seemingly outmoded and discarded idea of an anthropocentric nature. It deserves mention, however, that the attempt has been made since the turn of the century, and by a scientist of marked eminence: Wallace, who in his fever-tossed bed in the heart of distant tropics conceived of the modern theory of evolution simultaneously with Darwin, and whose discussion of the subject was published at the same time as the "Origin of Species." Wallace ever remained the naturalist, and so when he came to contemplate man's place in nature, his chemical, physical, and geological understanding proved sadly inadequate, and so his words fell far short of convincing the scientific world as once they, with Darwin's more carefully weighed phrases, had convinced it, in the case of the lesser demonstration —of the slow development of the higher out of the lower. Had Wallace been more broadly educated in science, one may well wonder what would have been the ultimate fate of these his thoughts:

> "The further back we go towards the innermost nature of matter, of life, or of mind, we meet with new complications, new forces, new agencies, all pointing in one direction towards the final outcome—the building up of a living sentient form, which should be the means of development of the enduring spirit of man."

It also deserves mention that L. J. Henderson, a biological chemist teaching at Harvard University, and a scientist of the most respectable reputation, in 1913 published a volume entitled "The Fitness of the Environment: An Inquiry into the Biological Significance of the Properties of Matter," and in this remarkable work—remarkable for clarity of logic and depth of conception—has as his final paragraph:

"There is one scientific conclusion which I wish to put forward as a positive and, I trust, fruitful outcome of the present investigation. The properties of matter and the course of cosmic evolution are now seen to be intimately related to the structure of the living being and to its activities; they become, therefore, far more important in biology than has been previously suspected. For the whole evolutionary process, both cosmic and organic, is one, and the biologist may now rightly regard the universe in its very essence as biocentric."

The especial aim of the argument is to show that the environment is in nigh to an infinite number of ways so strikingly adapted for life that we cannot explain away this fitness as merely the result of chance. That is, matter and energy form a pattern, as it were, at whose center is the chief figure, life. This inquiry was recommended to us as extra-curricular reading in connection with biology. That was ten years ago, and during the time since, I have noticed references to and quotations from this volume totaling up into hundreds. I have observed that not only biologists and chemists are familiar with the investigation, but also philosophers. I have also observed something else, a strange something: no matter how frequently or how extensively Henderson's treatment of his facts is quoted, either no reference is made to his ultimate conclusion respecting a life-centered universe, or this conclusion is lightly passed over as of no moment. Having had the opportunity now and then to mention this queer phenomenon to various scientists of established rank, and having carefully recorded and pondered their explanations, I gather that such final decisions as Henderson reaches are not to be considered today, as out of fashion. And what philosophers remark upon his conclusion are most evidently misinterpretations of its full significance. Physicists snort, and astronomers cannot forget the vast difference in size between mere man and any one of their stellar bodies. I wonder how many investigations of deep import are thus violently shoved aside by the sheer inertia of the rush of scientists along the lines laid down by their all too compelling leaders. On the other hand, the brave and carefree dash of physics, physical chemistry, and chemistry down narrowly delimited paths serves at once to escape the mental distress of examining theses like those of Henderson, and to keep out of the reach of the tentacles of teleology, which might otherwise writhe their way to fundamental atomic theory, hitherto untouched by the slime-begotten conceptions of biology.

Thus, in the present era of science, the evidence in favor of the ancient belief in a man-centered universe has been only once indicated by a first-rate scientist; however great his genius in his own specific field, his superficial grasp of the physical sciences naturally meant the failure to convey anything significant to an intelligent and scientific audience—whether or not he actually had anything worthwhile to convey. Probably his wild speculation tended to repel rather than to attract attention to the newer aspects of the old belief. And the sole effort of an irreproachable investigator with an irreproachable method of approach to the problem of the fitness of the environment for life in general (though not for man in particular), has been widely accepted as successful, only to be, to all intents and purposes, ignored afterwards in the philosophy of science and in philosophy itself. The scientists lack breadth of vision and the philosophers depth of scientific analysis. In such manner, then, I would interpret the unanimity of the negative educed in our poll.

May we not pause for a brief while to marvel at the vagaries of the stream of human thought? They are always fascinating, and moreover do have meaning here. Using that most potent of mental telescopes, dated literature, we can trace back the meanderings of our stream and perceive how it flowed past the banks of seventy-five years ago. What was its course then? Behold: then it murmured toward the south, whereas now it heads due north. Had we, seventy-five years ago, taken our poll, our canvass would have without exception netted affirmatives. Will that stream wander again toward the south? Why not? The obstructions now in its earlier channel are of evanescent material—soft masses of facts so long unexplained that we have become reconciled to their continued existence.

In plain terms, seventy-five years ago scientists saw so many really tangible miracles of preparation for the advent of man and took such account of them that, to every informed intellectual, only the assumption of design in nature seemed to explain this extreme adaptation of the environment. Today, these striking fitnesses of the universe for the origin, development, and progress of man are just as evidently facts as when they formerly crammed the literature of science and theology, but they are entirely left out of account, and altogether unexplicated. They are, you see, so old-fashioned.

We still have to dispose of the flippant. I shall have to do the best I can with that portion of them who answered "Who cares?" For I have the most naive comprehension of human nature. I know only what I incidentally see in the scientific papers—I find that in my leisure moments it is no different with me than in my working hours: I ever discover my mind besieged by myriads of spell-casting thoughts about anthropocentrism, perhaps drawn to my brain by the same strange sixth-sense that guides the sanity-lusting germs of hydrophobia to their central haunt, deep within the nervous tissues of man or beast. I fear that I have had no time for certain of the higher aspects of psychology, and have lacked the facilities for performing experiments as enlightening as this one:

"White rat suddenly taken from basket and presented to Albert. He began to reach for rat with left hand. Just as his hand reached the animal, the bar was struck immediately behind his head. The infant jumped violently and fell forward, burying his face in the mattress. Albert did not cry, however."

Poor Albert! I feel a certain sympathy for you; I believe I belong in your class. I do not know what the psychologists are doing, either. And like you, I am afraid of the intangible. Would not you too like to attack the matter of mind, safely and slowly, though infinitely slowly, through the pathways of physiology—rather than through fortuitous tunnelings into the superficial phosphorescence of that which is, being the brain of man, infinitely complex?

So I, like Albert, would leave psychology mostly to practical experience, common sense, and the novelists. And of these three I am sure I have nothing, unless it be the tiniest bit of the second: common sense. How do I know who cares? Therefore, I may logically be permitted only to express my own conviction. I, for one, consider it a matter of importance as to whether or not I am of more concern to the grandeur of the firmament than a louse or a bedbug.

I will, however, take it upon myself to ask: What if these 50,000 scientists are in error—as I am certain they are? Perhaps the philosophies of 1,000 other individuals are swayed by the opinion of each of these 50,000 men-who-know. Is it not a little dangerous to civilization that 50,000,000 intelligent, harried people are falsely led to feel that here nothing really matters? That we on earth are, as I have heard Clarence Darrow say, like so many rats in a cage—and for this reason alone, if it be a reason—should help one another out? From my point of view, it is more than a little dangerous if many of these 50,000,000 suffer from violent impulses (sometimes all the more violent for their subtlety) and a vivid imagination—both ever seeking an everlasting and solid foundation for constructive action, otherwise, in the last analysis, a waste of time—should all be but the gamboling gambles of chance, and should all be so quickly evanescent, leading nowhere but to the manufacture of a multitude of corpses whose rigor mortis soon lapses into the embrace of ptomaine-fattened maggots.

It is a more serious affair to deal with that second group of those who parried question with question, and answered "Why bother?" For I assume that a respectable amount of sincerity lies behind this seeming flippancy. Are we not here in contact with men very busy with practical problems, for want of whose solution we might all well be left in a pretty muddle of infantile paralysis, tuberculosis, cancer, diabetes, malaria, yellow fever, influenza, bubonic plague, famine, and a general panic surpassing the dancing madness of the Middle Ages by as much as the berserk stampede of an elephant horde does the scampering of frightened mice?

And yet, here we find that, as always, attitude is greater than aptitude. I admit that modern scientists have the highest technical skill and the most potent and most profitable technique of problem-solution in the whole history of civilization. But these same men-who-know see fit to exude a baseless philosophy as a sort of side issue from their work: "Humanity is but a transitory phase of the evolution of an eternal substance, a particular phenomenal form of matter and energy, the true proportion of which we soon perceive when we set it on the background of infinite space and eternal time." "Our own human nature which exalted itself into an image of God in an anthropistic illusion, sinks to the level of a placental mammal, which has no more value for the universe at large than the ant, the fly of a summer's day, the microscopic infusorium, or the smallest bacillus." At best, *we may or may not* be merely like disease germs, infecting a planet in its old age. Have these investigators, of undoubted attainment in their own specific fields, considered all the evidence at hand, as faithfully as though they were to report a new discovery to one of their learned societies? Much publicized astronomers make their popular works absorbing reading, but they also have helped to instill into the layman the illusion that not only do they understand the entire realm of science as well as their own infinitesimal, immediate pursuit, but also they are honest in their cynicism—which they cannot be, having neglected astounding assemblages of unexplained relationships. Is any one fool enough to doubt me when I say that this dishonest cynicism has had an overwhelming effect on the tens of millions? Furthermore, it is not childish for a serious mind to worry that science, in the popular mind, has cast man from the high throne which for centuries he was held to grace as the central, embodied idea of a planned and orderly universe. From every tiniest bit of practical experience we learn that we tend to live our thoughts—in lesser or in greater ways, in open fashion or in subtle act, now or later.

Therefore, I repeat, what avails aptitude, where attitude be lacking? To what advantage do the most glorious techniques labor, if their waste effluvia choke all ambition to use useful product? Fancy words, and fancier fancies—perhaps. But I maintain that there is a direct relationship between the number of atheistic and agnostic falsities pronounced by a given group of scientists and the number of lives preserved or made happier by the discoveries of these same men. Am I to pile absurdity upon absurdity, and attempt to relate scientific cynicism and narrow-mindedness with the efficacy of the efforts, say, of our incomparable public health service? Yes, even that. Note the following item from the New York *Times* of December 12, 1935:

Rise in Malaria Mortality

Malaria, a disease which has been held to be practically eradicable by any community willing to make the effort, has been increasing on a considerable scale during the last few years in the southeastern part of the

United States, according to the Metropolitan Life Insurance Company. Since 1931 there has been a definite increase in malaria mortality in each of the thirteen states in this area. Statisticians of the company report that "mortality from malaria, since 1931, has shown increases which range from 24 per cent in Missouri and Arkansas to 140 and 169 per cent in Louisiana and Mississippi, respectively. Between these extremes, Florida reported an increase of 95 per cent, Tennessee 80 per cent, and the rest of the thirteen states increases of between 33 and 43 per cent."

The *Times* is, as ever, conservative. Malaria has been time and again distinctly proven 100 per cent eradicable —by any community willing to make the effort. That a community is unwilling is due not so much to ignorance as to cynical half-knowledge. In the same public school science course, the insignificance of the human race is emphasized along with the significance of the anopheles mosquito. What avails aptitude if attitude be lacking?

It is not that the South is backward. I hope that I am not unfair when I say that New York (or any other large city) is far more the syphilitic or gonorrheal stronghold than it would be if practical-minded scientists were practical enough to have the courage of their convictions and lead the way toward dropping that preciousness of attitude which is the chief preventive of the adequate dissemination of prophylactic information—which they themselves have worked out.

It is truer than it is trite to say that man does not live by bread alone, or solely by quinine and plasmochin for malaria, arsphenamine for syphilis, chaulmoogra oil for leprosy, or by whizzing here and thereabouts in stream-lined cars, endowed with soothing or informative radios, whose internals boast a devil's dozen of the clearest-toned metal tubes, the latest suggestion of a Nobel Prize recipient.

Further, if it is pointed out to me that the lack of scientific proof anent the mosquito-vectored nature of malaria probably had much to do with the decline and fall of the Roman Empire, I can in return indicate that that multi-nationed collapse is to a larger and a more certain degree attributable to something else. The Romans suffered from no minimum of technical attainments. In their day, theirs was the proudest maximum of expert efficiency along practical lines. They were level-headed men, these Romans, but for this very level-headedness too practical to have upward vision, and to see that to be expert means frequently excessive, calamitous narrowness. A broad theorist and synthesizer like Aristotle should have been born among them—to make his mistakes, yes, but also to teach them the extent to which even the most specious of theories can suggest new lines of attack or can exhibit that rule-of-thumb methods have their childish limitations. Do I insinuate, blindly, that science has not its wide-grasping hypotheses today? Of course I cannot be quite so myoptic. There are, I wish to make clear, different levels at which the term "rule-of-thumb methods" can be disparagingly applied. The physicists, it is true, possess far more than a string of raw facts. They have their Newton and their Einstein, and so they have those actually stupendous laws expressing regularities from which consequences can be causally deduced—wherever a phenomenon occurs, in the bathtub or in the transcendently hot interior of a white dwarf five hundred million light-years distant. The chemists have had their Lavoisier, their submicroscopic-visioned Dalton, their omni-testing Faraday, their symmetry-conscious Mendelejeff, their X-ray-spattering Moseley, their atom-popping Rutherford. The biologists claim the age-enduring Aristotle; that Swede, Linnaeus, big but not dumb; the cell-discerning pair, Schwann and Schleiden; Pasteur, who bit the mad-dog; Darwin and Wallace; pod-wrinkling Mendel; and fly-torturing Morgan. Copernicus, Galileo, who was inattentive at church and discovered the laws of the pendulum, and who was further inattentive, this time to the church's dogma, and advanced our stellar knowledge; Kepler, who still lives, embodied in mathematical formulae; and Roemer, who first measured the velocity of light, than which thought alone is speedier; of these and others no less than they, astronomy can speak. And not a single one of these—physicist, chemist, biologist, or astronomer—but was or is a great generalizer.

What have I to say now? I have this to say: I nevertheless point-blank accuse modern science of suffering from narrowness of perception, which disease may also be called one-track mentality. I shall also add the charges of illogic, inefficiency, and carelessness. What is more, I shall prove that these apparently insane indictments have a firm basis in fact. There is reason to bother if a re-examination of anthropocentrism brings to light such defects in modern science.

There are different levels, I have said, at which the term "rule-of-thumb methods" can be disparagingly applied. If the thumb be theoretical, as it indeed is in the term, then it can without injury be projected into the fourth dimension or even beyond. That is, the thumb which is the unit of measurement can be a theory. As long as it works, well and good; if it is found too short, get a man with a bigger thumb. Thus it ever has been in the various divisions of science.

To give a tangible illustration: Up to 1828, there was a scientific rule that so-called organic compounds could not be made in the laboratory. Chemists believed that some special vital force presided over the manufacture of a plant or animal chemical product, such as the waste compound, urea—which man could not make in the laboratory because he could not there utilize *in vitro* what existed solely *in vivo.* Here was a rule of thumb—a rule based on practical experience, which is of course the source of all rules of thumb. But was it not an illogical rule, being a negative one? You cannot prove a negative. In fact, Wöhler in 1828 disproved this negative by the excellent method of synthesizing urea, which simply could not be synthesized—ever. He was able to do it because he had a slightly bigger thumb than any of his colleagues.

Thus originated organic chemistry and biochemistry. Once it was shown that organic compounds could be made, the chemists began to build up a logical system based upon those carbon compounds which they were readily able to synthesize. They worked forwards from simple to complex compounds, and then backwards from complex to simple, and then forwards again in new directions. By little rules and principles so developed, first one oil and then another were synthesized, first one alcohol and afterwards a different variety. Comparisons of the properties of the products and comparisons of the methods used in preparing them gave rise to larger principles, and new syntheses and new advances in theory steadily blossomed forth in the laboratory. Can we not call the earliest tiny principles, rules of thumb—but in no disparaging sense, since it could not have been otherwise, and since in every science a start has to be made somewhere? I do not think that any one could disagree with me when I say that, in the beginning, we had one level at which only rules of thumb were utilized—and of course necessarily so.

While organic and biological chemistries were developing, so was inorganic chemistry. In the latter, theories of the broadest nature have been successfully conceived, and in such a manner as to admit, in many cases, of no important exception. Thus, today, the theory of the electrical constitution of atoms and molecules works its seeming miracles in explaining and predicting phenomena. And yet, alas, attempt, as many have, to extend the electron theory into organic chemistry and then expect to meet with any satisfactory achievement if you pass anywhere beyond the mere threshold of the edifice of this science. From the viewpoint of the inorganic chemist, the organic chemist is for a long time yet doomed to work out his own destiny as best he can without any very inclusive electron theory, and with only rules of thumb to guide him. According to Andrade, great student of that greater, atom-bombarding Rutherford:

"The conflicts of certain organic chemists are best watched from a distance. I have no doubt that, as in the case of quarrels between man and wife, the participants are not dismayed by the fact that no result is ever reached, and that under all the noise and banging there exists a genuine mutual regard. At any rate wise men know what happens to the well-meaning party who, without any very clear understanding of the cause of the dispute, should attempt to interfere in such a fray. I have no desire to demonstrate his fate, or, if I may change the metaphor, die like a second Tarpeia under a shower of benzene rings."

He is making direct reference to attempts to extend the electron theory into organic chemistry. Do we not have here a second level—and an infinitely higher one—at which rules of thumb are the sole means of progress? Now I am not an organic chemist, but I know enough of the chemistry of the carbon compounds to understand perfectly well that I would have absolutely no right to speak disparagingly of this modern use of the rule of thumb method—apparently no other method of practical value lies at hand. (And yet, as I shall later explain, I do feel that had science in general a more efficient system of ordering its knowledge, such difficulties as those which confront the theorizer in organic chemistry would be the more rapidly dissolved.)

Therefore there is more than one level at which we can employ the term "rule-of-thumb procedure." As respects the disparaging application of the term, neglecting the Romans and coming down to the present, we have an excellent victim in that division of applied science to which the opticians belong. The opticians do not even have a textbook, and their lore is handed down from generation to generation by word of mouth or by demonstration. The lack of a textbook indicates the entire absence of theoretical interest. (To such men do we entrust the manufacture of that which should preserve what keenness of vision we do have.) Them I would disparagingly call worshippers of the rule-of-thumb. I have here picked on a very minor outcrop of the mighty field of science, but I have been seeking merely an illustration of the lowest level of the modern use of rule-of-thumb processes, rather than essaying to draw any great conclusions therefrom. If you misunderstand me, I would I had clung to the Caesars.

Mention has been made of the origin of biochemistry, about a century ago. Today this science exhibits strikingly and inexcusably that rule-of-thumb procedure which it justifiably and necessarily exhibited upon a lower plane in its earliest stage. Naturally I am aware of the really magnificent achievements of this ever-progressing division of biology: insulin, adrenalin, thyroxin, and the alphabetical vitamins are not unfamiliar substances. But broad theory in biochemistry is unfamiliar to us—and to the biochemists, too—and is inconspicuous because it is absent. Trial-and-error led to the discovery of the first vitamins, and to the postulation of the quite minor principle: Minute quantities of nutrient compounds are essential to the normal functioning of the body and for the prevention of certain diseases. The principle, once established by hit-or-miss, suggested that other vitamins could be found and they were found. Trial-and-error led to the discovery of the first chemical messengers of the body, or hormones, and to the postulation of the quite minor principle: Certain tissues, called glands of internal secretion, produce regulatory substances which are poured into the lymph and blood. The principle, one established by hit-or-miss, suggested that other hormones could be found and they were found, and are still being found. Narrow principles like these, there are. Broad principle, however, there is not. What would you have?—I may well be asked—Is not the living substance complex beyond all imagination and have we not therefore, in view of our practical successes, made a very good beginning? Unfortunate words: "a very good beginning." In a very definite sense, biochemistry has not begun at all. In a practical sense, it has begun. In a logical, theoretical sense, it has still to make a start. The biochemists are to be this time blamed for this short-sighted development of their science—the more so, that eminently practical considerations are involved also. Let us see.

What is chemistry? The investigation of the nature of the ninety-two elements and the phenomena associated with their combination and separation. Has chemistry carefully studied these simple substances, or elements, so that their individual characteristics are well understood? Yes. Then chemists have made a logical beginning. Has this study led to the enunciation of broad principle and the prediction of phenomena otherwise unpredictable? Yes. Can you provide an illustration? Symmetry-conscious Mendelejeff in 1869 found that the investigation of the elements had proceeded far enough for him to make a comparative study of their properties, and he was amazed to see that by means of a symmetrical chart he could arrange the elements into families and groups. Knowing the family to which an element belongs, a chemist can, without ever having seen the element, predict altogether successfully what the weight of the element is, the violence of its activity, what other elements it will choose to summon to its soirées and lovingly embrace, what other elements it will rout out of house and home, and even what the color of its compounds will be. That is true because elements in a family, as even with human families, have many attributes in common. In fact, when Mendelejeff, for want of elements to fit into certain blanks in his chart where he was convinced elements should go, had the courage of his convictions, predicting the properties of these unknown elements, he did so in such accurate fashion that his associates even knew where to go to hunt for them—and discover them. Chemistry has indeed made a very good beginning.

What is biochemistry? The study of the activities of such of the ninety-two chemical elements as enter into the composition of living things. That is interesting. Only certain elements can be used by that which being alive we call protoplasm. What are these elements? Well, we have not yet determined the full list; the problem is of vast complexity, in view of the astounding intricacy of the life material, and in view of the fact that certain elements, such as copper in the case of man, are required in such extremely minute quantities. Fair enough. But now, let us see—suppose I were to define a life element as follows. "A life element is an element which has been shown to be definitely essential to at least some living form." How many life elements are there? Well, no biochemist knows.* What! Why not? Well, he could find out after some months spent reviewing the literature describing what men have accomplished along this line. No one has as yet taken the time to organize our knowledge of the bioelements—indeed, why bother? Nobody in biochemistry has time for such efforts. Science is past the stage where discoveries can be made in the library. (How often have I heard this assertion!)

Thus there exists nowhere, in any language, a comprehensive discussion of those elements which enter into the composition of protoplasm. Biochemistry, after one hundred years, has not commenced to examine its fundamentals. Since in living matter elements exhibit phenomena to be observed nowhere else; since protoplasm involves a sort of higher physical chemistry of the elements; and since there are already known to be remarkable correspondences between the positions of the ele-

* After a careful weighing of the literature, and extending my effort over a period of five years, I have determined that the number is twenty.

ments in Mendelejeff's chart and their physiological roles, one might expect that a consideration of the features common to the bioelements would have merited at least a moderate effort. It is small wonder to me that scientists complain of the overwhelming vastness of their accumulations of facts, that they say it is so difficult for a man in one field to learn what is going on in another and even very closely allied division, and that they admit a longing for a better means of organizing their aggregations of discoveries. In any large business, the most logical and intelligent classification of records is one of the first and most important preliminaries to profit. How can science in general long show profit if its great departments illogically, inefficiently, and carelessly neglect an examination of their basic principles—which examination is the sole approach to successful systems of classification?

Let us further question this astonishing man, the biochemist. Aside from the fact that you have seen fit to remain in the thick of the fight, rather than to retire now and then to the sidelines to observe the course of events, and to contemplate how best you can turn the turmoil to your own amorphous purposes, and aside from the fact that to proceed in accordance with logic has at least its esthetic rewards, do you not really believe that some practical advantage might be derived from theoretical considerations concerning the elements of your science?

Mendelejeff accomplished far more for the world in the hours which he spent in his library than in the years which he labored in his laboratory. Here was a man with eyes keen enough to penetrate the blackest mists of the unknown, perceive there a new substance, never dreamed of before, observe its appearance and even that of its compounds, accurately weigh it and even its compounds without the use of a balance, and tell you where to look for it on earth.

Now, the life elements are peculiar, if only because they are life elements, whereas dozens of other elements are not. Is it not possible to imagine that these bioelements have in common a special group of properties, which no other elements have, and which would enable the biochemist, if he were aware of them, to predict what elements, hitherto not known to be life elements, should be definitely suspected of being such? Would this not facilitate research and indicate to the investigator what elements he should very carefully consider in relation to physiology, or more carefully consider, if he should already have superficially dealt with them? Copper was found in human analyses a very long time before scientists began to suggest that it might be required in human nutrition. And it was a long time after the suggestion that serious investigations were undertaken, finally to bring proof that copper is as necessary to man as iron, iodine, calcium, or phosphorus. Scientists are prone to boast that no common-sense angle of attack upon a problem is neglected. The scientists so boasting are in error.

I am not a biochemist. But I do know enough about the use of chemical elements by protoplasm—the life material, made up of nothing more or less than chemical elements harmoniously conspiring to create vital phenomena, even unto sensitivity, memory, emotion, will, and wide-eyed vision—I do know enough about the use of chemical elements by protoplasm to assert at least the following characteristics of a life element: it is to be found among the most abundant elements in the crust of the earth,* it is an active element, it is light,* it has sharply defined properties, it consists of no more than three isotopes (varieties of the same element), and almost without exception is to be found associated with those difficulties which prevented Mendelejeff from making a perfectly symmetrical table, i. e., where this symmetry-conscious man had to force things a bit, there, as a rule, we find a life element. As an instance of this last,

* Iodine excepted.

we can take the case of hydrogen. It is a life element than which there is no more important—and it has no logical position in any symmetrical chart of the elements yet devised. Or the case of carbon, silicon, vanadium, manganese, copper, boron, or potassium—each directly connected with some asymmetry of Mendelejeff's arrangement, and each a life element. Oxygen and nitrogen, life elements, are atypical in this sense: each is so different from the other members of its family that when we examine it closely, we may well suspect it of being, as it were, a bastard in the group. Briefly, nearly all of the bioelements are peculiar elements, and do not quite belong where perhaps-too-symmetry-conscious Mendelejeff put them. The life elements are *different* elements, therefore. One might be tempted to suggest to the bioelement-seeking biochemist that he ponder a little more earnestly the cases of those elements which are abundant, widespread, active, light, possessing sharply delineated characteristics, consisting of at most three isotopes, and being somewhat more than slightly peculiar in the widest chemical sense. Name one? Yes, nickel. Another? Yes, aluminum. But some say aluminum is already proven a life element. Yes, some say so—but examine the literature carefully. There is far from sufficient evidence to justify the conclusion that aluminum is demonstrably essential to any form of life.

As additional evidence that the scientist, and in particular the biochemist, is inefficient because narrow, I can point out that the biochemist, having neglected fundamental theory, has been guilty of allowing a common-sense and promising angle of attack upon disease to escape his notice. A detailed consideration of the life elements, would, together with a logical system of classifying the knowledge that is physiological chemistry, have long since brought into suggestive juxtaposition these two facts: first, certain elements, such as zinc, are termed oligodynamic elements because exceedingly minute quantities of them produce remarkable effects upon lower forms (and perhaps higher forms); second, disease germs, which are low forms of life, have been poisoned, burned, dried up, electrocuted, and otherwise tortured into submission to man's intellect, but in several cases the disease has defied all attack—all conceivable types of attack—except one—starvation by elimination of oligodynamic elements.

As early as 1870, Raulin found that the growth of molds, such as common bread mold, is markedly favored by the merest trace of zinc or manganese. Molds and bacterial germs are exceedingly closely related, and molds themselves are often pathogenic. With any disease for which there is no cure, has any man of research first infected a laboratory animal, and then fed it the purest of food—so pure as to be entirely free from the least traces, say of zinc or manganese? No. I fully understand the difficulty of the technique, as food does absorb traces of metals even from the containers. You eat the more tin—though harmlessly enough—for the use of vegetables canned in tin-clad iron. Yet the technical difficulties are as nothing in comparison with the seriousness of the research. Perhaps, without its stimulating zinc or other oligodynamic metal, the injurious microbe might find its rate of multiplication damped to just that extent which would enable the laboratory animal (or man) to repel the invasion and recover. Who knows? And to the biologist who cries "Gross speculation!", I would reply—"Are you not the same biologist who, ten years ago, made the headlines which informed us that at last science had solved the immense problem of crime? And by the simple process of adjusting the malfunctioning of the glands, like the thyroid or the adrenals, which secrete chemical messengers—which you at one time led us to believe in no uncertain way were the sole important factors in personality?

"Many a scientist in this great era of the game of follow the leader rushes past the leader and bursts onto the front page of our daily papers, there to announce in high-toned terms what is the next day refuted in lesser print, which looks so minute beside the advertisements of your latest book. When I refer to your neglect of oligodynamic elements as related to disease-contol, can you sincerely call me speculative—if you are just recovering the breath you wasted in loud barking up the wrong tree? Better you had preserve that breath for later barking on your own account, for to the scientist whom the gods would destroy, they first give publicity. There is something about the scientist who has tasted the headline, that is remindful of the psychosis fastening itself on the nervous system of a Bengal tiger after its fangs have once punctured human warmth. And front-page speculation is more the pathological pituitary giant than is calm suggestion."

Still harping on what is to be scientifically gained by a tardy though logical consideration of the life elements,—have you ever asked a biologist to define a species? If so, you will recall that the most enlightening impression that you derived was that "a species is a group of animals or plants that has been defined as a species by a true biologist." Has it ever occurred to your biologist friend that it would appear possible to obtain more accurate information respecting the nature of species, by a more careful investigation of the intake, use, and outgo of the elements concerned in the organization of given types? Structural differences which enable us to distinguish between different species have their bases in chemical differences. Different living things use different elements or different quantities of the same elements. To obtain clear definition of a species, it might be necessary merely to determine the weight of each life element found in the ash of the ant, mold, or other form in which one is interested. Different weights, say of copper, would in the case of two very similar forms mean two distinct species—between which the eye alone would have difficulty distinguishing. Using first-class technique, such tests might be made extremely delicate and altogether satisfactory. The point is that this approach to the problem of species has never been tried. Why not? Biology chooses to neglect fundamentals. And afterwards complains of chaos.

A score of centuries ago, omni-pondering Empedocles was more element-minded when it came to a question of livings things than any modern scientist:

"When the elements have been mingled in the fashion of a man, and come to the light of day, or in the fashion of the race of wild beasts or plants or birds, then men say that these come into being; and when they are separated, they call that in common parlance, death . . . let not the error prevail over the mind that there is any other source of all the perishable creatures that appear in countless numbers."

The average man would be sensible enough to prefer today's bathroom to all the glory that was Greece. Nevertheless, there is something to be said in favor of the days when men had broader vision than our men of research, though no keener minds. For I am not one of those who believe that the intellects of the ancients were better than ours. There were no greater giants in the earth in those times. But I am certain that, give a few of our foremost scientists a sip of Socratic self-doubt and if they do not call for a second sip, this time of the hemlock, then they will clamor for a bit of mental dynamite to blast the rut into which science has so deeply and so unconsciously sunk.

Empedocles introduces us to the supreme illustration of illogic, carelessness, narrowmindedness, and superficiality of investigation characteristic of the entire realm of science in 1935: the century-enduring debate between the vitalist and the mechanist. No matter how lengthily the vitalist argues, still he can never conceal this fact: A vitalist is a scientist who believes that a scientifically unknowable force is what makes a living thing live. Not all the beautiful prose of Bergson in his *L'Evolution Creatrice* can remove the suspicion that, were he an aborigine for the first time contemplating a Ford car, he would ere long start describing in the most refined Patagonian how that great arbiter of all things automobiline, Henry Ford, had at a certain stage in the evolution of his machine instilled an integrating and harmony-inducing mystery—a psychic force, at once tangible and intangible, simultaneously measurable and non-measurable, at the same time scientific and yet science-transcending, ghost-like but not fading at the dawn of common sense.

I have always been led to believe that the major support of the whole edifice of science is the faith that nothing untouchable and nothing non-measurable exists in the universe. Deny this dogma, and immediately there is a rush of invisible devils into your laboratory. They, in high glee, whisper psychologist-baffling logic into the ear of that white mouse; inspire this ameba to confound his observer by shaping his pseudopods into the letters of the Sanscrit alphabet; bombard the physicist with his own atom-bombing apparatus; and in general kick up such a dust that not only are the scientist's bacterial cultures contaminated but even his incomparable reason.

Have I not heard, the vitalist may inquire of me, that physics has become lost in metaphysics chiefly because it has met up with infinitesimals—data of a magnitude so insignificant that they escape the observation of our senses—such tiny considerations that even Einstein can perceive no way of measuring them? I have also heard that Einstein measured what Newton could not—and in genius Newton possibly surpasses any man who ever lived. May not a Newton be born again, in his turn to do some unfuddling? And I refuse to cherish the opinion that the giant, personified physics, is going to trip over an infinitesimal and bash out his society-revolutionizing brains upon the altar of mysticism.

And the dreams of man—have I not heard whisper of these? Are they measurable? Who can say? Perhaps there is yet time, though our creation be finite.

Thus I say that the vitalist, wherever he be found, in physics, chemistry, biology, astronomy, or the new-growing hybrids of these, when he breathes into the ultramicroscopic virus or into himself a mystic vital impulse, unknowable of science, thereby denies the value of his scientific method. Scientifically and logically, only in the earliest beginning could the finger of Fate have woven the web of life—preparing for it in the architecture of the elements when first they were designed, aeons before they collaborated in corporealizing the central scheme of the cosmos.

No matter how lengthily the mechanist argues, still he can never conceal this fact: He explains that life is the supreme example of the harmonious and enduring interplay of those physico-chemical regularities with which he deals upon an almost infinitely lower plane, and at the same time explains life away as the supreme example of the operations of the law of chance. Not all the hieroglyphical beauty and fascinating prestidigitations of his mistress, mathematics, the queen of the sciences, can remove the suspicion that, were he judge and jury at any murder trial in the history of civilization, no matter what the evidence, circumstantial or direct, no matter whether or not he had actually seen the accused commit the crime, still he would have directed and pronounced a verdict of *innocent,* making his judgment ponderous with massive prayers to his goddess, Chance—lest she meanwhile whimsically indulge her fancy for sublime concatenations of chance occurrences, accidental integration of chaotic distintegrations, and fortuitously correlated surges of molecules, and induce a sudden unlucky excursion of his component atoms, to blast him into a cloud of smoke that would float out of the window of the judicial chamber and up toward her kingdom which he served so well on earth.

As a matter of fact, mathematics should rather not shield the mechanist from any suspicion of illogic but turn upon him and convict him of the crime of omitting from his reasonings the odds against the chance formation of living things and man. What are the odds against the accidental production of a definite type of star which should in random fashion give forth unconceived a moon-attended earth, luckily of precisely the appropriate size, shape, solar distance, axis-tilt, and fortunately composed of ninety-two elements; these elements occurring in precisely the required abundance and having just the needed distribution, not during one year only, but during billions—also by chance exhibiting countless millions of properties and activities peculiarly favorable for the origin, endurance, and development of an environment, itself a vast system of astoundingly intricate systems, all by accident uniquely fitted for the origin, endurance, and development of quadrillions of interdependent living mechanisms, each in its complexity more awesome than the imagination-wearying stellar distances and nebular magnitudes of the over-emphasized astronomer, and each by the merest fortuity capable of being constructed of less than twenty elements—

whose billions of chance rhythms, harmonies, and themes should happen to conjoin in a consonance that is blended of earth, earth-evolution, moon, moon-evolution, planetary motions unending, sun, solar evolution, nebula, and nebular evolution—even of the universe and universe evolution? Should the astronomer desire really to stupefy us, he should turn his telescope upon the earth, and there find a midge. Afterwards he could set himself the task of calculating the odds against that midge's existence—and he himself would be stupefied to determine that, when all factors were accounted for, that midge simply could not be there. Yet there it is: though the chances against its existence are greater than any in human experience, and the figures involved in expressing the odds could not be fitted into the astronomer's farthest-flung reaches. In brief, the odds against the chance origin of life are so great as to be incalculable.*

Thus vitalism and mechanism become one. The mechanist cannot account for the existence of living mechanisms by falling back upon the laws of chance. He, like the vitalist, must assume that, in the beginning there was woven into matter and energy the pattern which we now observe so wondrously unfolding. No vital force has ever entered into the workings of the cosmos—except at

* See Chapter V.

creation's conception. And apparent accident after apparent accident, in an endless series, all necesarily occurring harmoniously to give life to man, lead us beyond the realm of chance, to the inmost heart of the region of purpose, and to the very foundations of the architecture of things.

In this connection, it is interesting to note how many times the expression "lucky accident for man" or similar phrase occurs in the popular writings of modern scientists. But it is not that I am against mentioning these instances of accident (or seeming accident) and terming them chance phenomena, it is rather that I strongly resent the reference to such a small number of them. For example, why does one writer distort the ideal form of his description of the universe around us by expending a paragraph on the lucky accident of ozone? Even so, he was far from full-formed completeness. I suggest that his too brief paragraph should include the following: That the accidental effusion of death-rays from the accidental sun, by an accidental mode of transmission through an accidental void, strikes the upper portion of the accidental atmosphere of the accidental earth, and there accidentally induces in the accidentally evolved element oxygen, the formation of the accidentally unique substance ozone, or triplet oxygen, and thus accidentally creates that ozone-filter which makes them become not death-rays but life-rays, which are accidentally able to penetrate with the accidentally appropriate intensity and wave-length to the accidentally harmonious conglomeration of accidental elements that is man, and in him effect a sublime series of accidents culminating quite accidentally in the accidentally physiologically potent vitamin D, itself an accidental factor in the accidental web of intricately-accidental life, upon most if not all of which man accidentally depends and accidentally finds fitted for him. And that this same oxygen is accidentally able to help bring about the effusion of death-rays from the sun, in which it is accidentally present and in accidentally suitable proportions: is accidentally one-fifth of the atmosphere, accidentally 88.89% of water, an accidental substance accidentally adapted in countless thousands of accidental ways to the accidental evolution of the earth, to the accidental origin of life, to the accidental endurance of life, to the accidental development of life culminating in the accidental blossoming forth of man—and so on, actually ad infinitum.

Now this can be said in no sarcastic vein: one may well become so blinded by the splendor of the heavens and so apoplectically incoherent over stellar magnitudes and distances, that one has not eyes to see or words to express the mystery of the lowliest form that oozes in dank Earth, itself, at first thought, so negligible a bit of parasitized ash floating far down the gulf of space-time.

Need we now mention how biophysics too, disregarding its fundamentals, has been sadly neglectful in incredible fashion; how pharmacology, the chemistry of drugs—chiefly those usable by man, himself a protoplasmic colloid—is just now learning colloid chemistry, after fifty years; how the textbooks of science are on the average about fifteen years behind the times of new fundamental principles; how philosophical scientists miss the basic principles of other sciences than their own, and hit the bloated insignificances—swollen and large-looming because proud of being new? How above all, we observe chemistry and physics, sticking to rule of thumb, narrow-mindedly leave out of all account that peculiarly suggestive, and unique, extreme height of physical chemistry, the life system, in which elements and forces co-operate enduringly and dynamically—as they do nowhere else in the cosmos?

The chemist and physicist cannot say that such considerations are the work of the biochemist and biophysicist, because in the inconceivably complex web of science nothing should be left uncontemplated. Common sense alone would indicate this attitude. Science has demonstrated that the universe is a linked system, i. e., discoveries in one realm have bearing in all other realms of knowledge. We have spoken of hybrid sciences, such as physical chemistry, biophysics, and biochemistry, and of course there are many others, including astrophysics and geochemistry. Indeed, the recent history of science exhibits nothing so striking as the universal breaking down of the barriers separating the formerly individual fields—unless it be the simultaneous piling up of fact-obscuring mountains of facts—which disorganized condition is to be in part attributed to poor methods of classifying information as it is brought to light and in part to the sportive mood which impels men of research to expend the major portion of their efforts in a gargantuan game of follow-the-leader.

The scientist whom we have long revered as the acme of efficiency could really be profitably original and inquire of the industrial efficiency expert as to the main requisite of successful classification of records. Of course the first requisite is to divide the field of endeavor into logical units—and this step science has taken, in admirable fashion. But after analysis should come synthesis—the sole means of interpreting and profitably using detail. Synthesis is impossible without broad theory.

What broad theory? Science has no all-inclusive theory, save it be the gambling guess that all is the play of chance. Chance having so well favored man thus far, possibly chance will see fit to establish a central bureau of fact-organization, and with unerring intelligence, send out information of its activities to all interested scientists. Or perhaps, to the vitalist lost in his accumulations of unrelated knowledge, some mystic spirit will convey soul-delighting inspiration and guidance.

What broad theory? Why not a simple hypothesis not in conflict with any facts, rather explaining a world of facts not now explicable, and one having pragmatic recommendations, as centering about man, himself the central figure of the material world? I refer to the hypothesis that from the primary dawn to the moment the missing link was by Nature misplaced, each and every phenomenon has been directly related to man's advent. This should be our broad theory, upon which is to be based our logical classification of that knowledge which man is through thousands of decades amassing. And without logical system of ordering that which he discovers concerning this place of order, our universe, the scientist will not only be lost but ultimately irretrievably lost—as many think he is already.

Referring again to our almost forgotten poll—those who, answering "Yes or No," have not made up their minds, we had best warn to emulate, before they reach final decision, the Roman emperor of whom the historian relates:

> "All night long he sat alone over his papers in his cabinet, or paced the dark halls in deep thought, so that it came to be whispered that he was no mere man, but an evil demon requiring no sleep."

Perhaps they had best thus lose sleep pondering how run the papers of science, ere they gamble with Chance or carouse with ghoulish entelechies.

Should I by accident have aroused some liking for such thoughts as mine, I can refer the interested to Henderson, Wallace, and the Bridgewater Treatises of last century—not to mention those men who envision things whole—the poets—and in all these to find much that is thought-provoking, though of course to be carefully criticized, re-interpreted, and infinitely extended in the light of modern discoveries. Much of error and childish extremes will in these also be perceived, except in overly conservative Henderson. And in addition, may the astronomy-charmed and nebula-awed note much of charm and awe in facts like these: That as you read these words, your thoughts—as is demonstrable scientifically and mathematically—have a choice of paths greater in number than the atoms in the most gigantic nebula; that your thoughts do not run wild over these paths is because they are regulated and rendered harmonious by purpose-motivating influences like seemingly chance-created fear, or hate, or anger, or life's ineffable mystery—love, in our so-called random evolution a factor by men-who-know ignored foolishly, since we with common sense have seen it lift a man out of the clasp of Mendel-inherited alcoholism, Freudian-suggested sexual insanity, and chromosome-made stark despair, and breathe to him of hope and energy illimitable.

We have taken an imaginary poll of 50,000 scientists; have received a unanimous negative to our great question, together with some comments to boot; have given answers to those who retorted query for query; have called the unanimity, cocksure; the uncaring, dangerous; the unbothered, befuddled; and the undecided, sleepy.

I may be wrong. Innumerable phantasms creep about the murky limbos of the cranial cavity, evolved and inherited from creatures that once lurked in the never-ending dark and chill of the maddeningly silent ocean deeps; from three-eyed, be-tentacled monsters whose icy hearts palpitated cannibalistically for the plasm of their own kind; from flabby, backboneless, puffy kin of the ink-spitting octopus, and others of Nature's dreadful corporealizations, whose earlier history is buried in the musty dust of ages rotting on top of ages. I may be indulging one of these creeping phantasms. Yet logic is logic, whatever the use made of it. And when that Indian-giver, the metaphysicist, takes back his logic—well, we can still utter up thanks to heaven for leaving us that which transcends the purest reason of Kant himself: common sense. I believe it is common-sense that will in the end bring you to agree with me that 50,000 scientists can be wrong.

CHAPTER III

My Enemies—the Teleophobes

KARL ERNST VON BAER* said that those scientists who found no evidence of purpose in the world suffered from *teleophobia,* or fear of purpose. Now, in this particular work, I am not interested in demonstrating the presence of purpose in the universe. Rather I am showing that the universe is made according to a pattern whose central figure is man. Thus, purpose does not here enter into my considerations. Nevertheless, the teleophobes will be my enemies.

That is, the teleophobes will see that my line of proof is, in some of its parts, remindful of the evidence brought forward many times in the past in favor of the existence of God. Individuals who suffer from a phobia cannot or will not see clearly. The teleophobes therefore will be only too eager to class my logic with the illogic of time-battered natural theology and—if they do go to so much trouble—hasten to tell me that this line of argument has been so often demolished that I

* The father of modern embryology and one of the great figures in nineteenth century biological research.

am merely showing my ignorance of the history of the science-religion conflict and should know better.

Then, since I am aware of the prejudices and scorn of the teleophobes where anything seems to hint of the cosmic dignity of man, does it not follow naturally that I should at least warn against these unreasoning feelings and make it very clear that my cinema-like depiction of the world as known to science should logically not be a stimulus to the emotional responses of teleophobia? Even though I should not in this way prevent the teleophobes from attacking me, the warning, I hope, will help to lessen the dismay of those who might at first lean toward my view and then find themselves at bay before the onslaught of a host of teleophobes having the highest scientific reputation.

A mere photograph of things-as-they-are should not stimulate antagonism—especially if the photographer be honest, did not make unfair use of lighting-devices, distorting lenses, or other misleading inventions, and did not touch up his camera-study. If other minds than mine, when they observe the pattern of the cosmos-photograph, choose to feel that a design must have a designer and that the pattern proves the existence of Divine Intelligence, this bit of illogic is no affair of mine and should not be allowed to obscure the value of an accurate, scientific, and pattern-demonstrating camera-study of the universe. Even so, I know the excesses of teleophobia, and therefore I am taking care to indicate my awareness of the following events in the history of the belief that the universe can be shown to move according to an all-inclusive plan and toward the fulfilment of a purpose.

The idea of a purposive cosmos can be traced in written records at least as far back as the time of Babylon, whose astrologer-astronomers saw the hand of a Divine Power behind the regular motions of the celestial bodies. Thus, when Plato came to examine the evidence in favor of a planned universe, certainly some of the evidence had been pointed out over three thousand years before. Plato found that the great movements of the universe exhibit regularity and order, and this belief he made part of his argument for the existence of a supreme cause of the universe, the One Perfectly Good Soul, which, being perfectly good, necessarily governs the cosmos justly and wisely. Aristotle also found evidences of design in Nature, and was led to reason that the universe owes its existence to an intelligent Author.

Aristides, in the first extant Christian Apology said:

"I, O King, in the providence of God came into the world; and when I considered the heaven and the earth and the sea, the sun and the moon and the rest, I marveled at their orderly arrangement. And when I saw that the universe and all that is therein are moved by necessity, I understood that the mover and controller is God."

The medieval Schoolmen carried on this tradition of contemplating the "book of Nature," reading therein, and believing that they had thus learned of God. Raymond of Sebonde, that Schoolman of old, wrote *Liber Naturae,* and expressed thoughts almost identical with these of the much later Sir Thomas Browne—whom one would prefer to quote because of his greater eloquence:

"There are two Books from whence I collect my Divinity; besides that written one of God, another of his servant Nature, that universal and publick Manuscript, that lies expans'd unto the Eyes of all, those that never saw him in the one, have discovered him in the other: this was the Scripture and the Theology of the Heavens; the natural motion of the Sun made them more admire him, than its supernatural station did the Children of Israel; the ordinary effects of nature wrought more admiration in them, than in the other all his Miracles; surely the Heavens knew better how to joyn and read these mystical Letters, than we Christians, who cast a more careless Eye on these common Hieroglyphicks, and disdain to suck Divinity from the flowers of Nature."

And so the *argument from design* unobtrusively persisted—almost unchallenged—through the centuries and the ages, through the Rennaissance and the Reformation, until in 1779 it was for the first time seriously criticized in Hume's *Dialogues concerning Natural Religion.* This attack stimulated an unequalled development of the argument, and this development reached its height in the *Natural Theology* of Paley (1803) and in the eight *Bridgewater Treatises* (1834-1840).

And so, for well over five thousand years, thinkers fallaciously argued: "Design supposes a designer. The world everywhere exhibits marks of design. Therefore the world owes its existence to an intelligent Author." Then, when the influence of this "proof" of God's existence was at its widest—when the general run of Western minds most unsuspiciously accepted the argument from design—at last the fallacy involved began to be made known to many thoughtful people and afterwards to the ordinary layman, perhaps chiefly because of the growing realization of the correctness of Kant's analysis of the "proof" in his *Critique of Pure Reason.* In this work, Kant showed that no logic yet known to man justifies the assumption of a Designer simply because the universe exhibits design, i. e., purpose. Thus, even if you are able to make evident to every one the existence of a man-centered scheme of things and show that the universe was intent upon the development (unfolding) of man, it is not logic to say there was a Grand Planner behind the All.

Now Darwin came. At once Paley and the *Bridgewater Treatises* were out of date, since they took no account of evolution, and their arguments were all based upon the idea of Special Creation, not upon a slow, natural, mechanical becoming. Therefore, our final judgment of the argument from design, as expounded by Paley and the authors of the *Bridgewater Treatises*—and many others in later years and even in modern times—is that the reasoning involved is fallacious and the facts used are in great part unscientific.

I am also aware that the most widely accepted description of the cosmic evolutionary process, organic and inorganic, is remindful of a description of the course of the winds: according to the majority of present-day scientists, the ascent of men from primordial cells provides no more evidence of design than does the path of a storm-cloud. There exists no scientist, nor has there ever existed any thinker, whose science and logic are above reproach and at the same time show man to be other than an accident. Bertrand Russell can therefore write in 1936, "Man is an accident in a backwater of the universe," and feel secure that no one, with any scientific reputation, is at hand to dispute this judgment.

The Vatican Council of 1870 endorsed the attitude that: "If any one shall say that the one and true God, our Creator and Lord, cannot be known certainly, through these things which have been made, by the natural light of human reason: let him be anathema."

The writings of the scientists of 1936 endorse this attitude, that: "If any one shall say that by the natural light of human reason and through an interpretation of those things which are in existence, man is to be considered as no accident: let him be anathema."

But I have said that my chief aim was to demonstrate that the all-subsuming pattern of the universe has had man as its central theme. To the teleophobes I shall be anathema. And yet does the fact that the argument from design has ever been—in every one of its forms—fallacious and unscientific affect in any way whatsoever my specific purpose, the aforesaid demonstration? Does the fact that the accepted description of the evolutionary process portrays man as an accident, really mean that no other logical and scientific description is possible? Is it actually altogether impossible that a large number of eminent men—eminent in their own narrow fields—should make a major error in a field requiring breadth of vision? Each one of these questions I would answer in the negative.

I am not urging the ancient argument from design. My logic is correct logic. My facts are scientifically acceptable. Nevertheless, I realize that if I am to withstand the attacks of the teleophobes, and other good logicians, and if I am to prove that man is the product toward which all cosmic forces, materials, and their properties and relationships have worked, then I shall first have to answer thirteen objections:

The First Objection

Apparently, man is not as perfect a creation as we might imagine he would be if he were really the center of cosmic activity. The eye, for instance, has not passed unnoticed by the teleophobes:

"Any optician who should manufacture an instrument as grossly imperfect as the human eye, would be hooted from the trade as an ignoramus and a bungler."*

In general terms, then, man's organs are seemingly not as perfect as we might imagine they could be.

Moreover, man possesses useless organs, such as the appendix. Being useless, they are obstacles to completely satisfactory body functioning, and are also sometimes, like the appendix, even dangerous, as susceptible to disease.

* Article on "Design in Nature," *Westminster Review,* July, 1875.

Finally, man is imperfect—apparently—because he does not have organs which we might fancy he should have in a perfect world. Why, for example, could not man have evolved organs sensitive to electromagnetic waves as short as X-rays and as great in wave length as radio waves? Then he would readily see not only the tiniest disease germs but also find it a simple matter to investigate that greatest mystery of modern physics, the nucleus of the atom—and then perhaps the almost limitless energy-possibilities of the atom would be his to take advantage of immediately.

The Second Objection

The environment of man is excessively dangerous. His very existence as a living being hangs by two inconceivably fine threads: his will to struggle and his ability to achieve practical results. Let one of these threads snap, and the race vanishes into an inescapable, murderous sea of storms, ice, parasites, famine-causing and dwelling-destroying insects; tidal waves, foul and poisonous waters; suicide-intent, warlike, and blindly-stabbing traitors to civilization; and insanity. It is a miracle: man has so long survived. Will he not die soon?

The Third Objection

If Nature has been "intent" solely upon the development of man, then Nature has been very wasteful in the process. "Where is now the long travail of Nature that went uselessly into the dinosaurs"* and millions of other extinct species?

The Fourth Objection

The living stream of organic evolution has had many apparently aimless meanderings—it has not flowed straight to its destination, Man. That is, Nature "experimented with" millions of forms before hitting upon the scheme embodied in the intelligent mammals and culminating in the human intellect.

The Fifth Objection

Man may not represent the height of evolution. Higher beings may already exist, or higher organisms may evolve from the human race.

The Sixth Objection

Could not the physico-chemical conditions of the earth have been different, and other forms of life than those with which we are familiar have appeared? That

* Edmund Noble, *Purposive Evolution,* p. 38.

is, apparently life might have made use of other chemical elements and compounds or of other types of energy and unfolded in shapes far different from those known to biologists. For all we are aware of, some scientists say, whatever the conditions on a planet, life might take its rise. There might be weird creatures, unimaginable of man, on the eerie surfaces of planets circling a strange sun in some utterly unknown region of our little known universe. As expressed by Barnes, in his *Scientific Theory and Religion:*

"One is left with the feeling that, even if carbon, hydrogen, and oxygen had not been available, life might have found elements which would have been adequate for its needs."

And as expressed by a more popular author, in *The Science of Life:*

"Life on any other planet besides the earth would have to be so different in its character from the life we know, that one would almost need another name for it. If we call terrestrial life Alpha life, we might call the life-parallel on Mars Beta life, an analogous thing and not the same thing."

Wells and his co-authors do not specifically state that, in their opinion, life exists elsewhere than on the earth, but rather that the speculations of scientists suggest the high probability of living things upon thousands of globes located at intervals throughout the universe. *The Science of Life* does say that we can conceive of silicon taking the place of carbon in some ultra-mundane life economy.

Thus, if man had not appeared, some other high—or higher—form has or will, and if not on earth, at least somewhere.

The Seventh Objection

Many factors in the cosmic formula do not seem related to the origin of man. What possible relation has the nebula in the constellation Andromeda to the genesis of tiny bits of humanized scum on the rotting top-inches of a minor planet of an insignificant sun? And what connection is there between the flaring up of a star into a nova, one hundred million light-years distant from the earth, and the descent of man from an ape-like stock?

The Eighth Objection

Man is the outstanding freak of Nature: at once the most complex known organism and the personification of fortuity. Can any one name a scientist of reputation who has not stated that man is the offspring of chance? In short, all scientists are agreed that man is an accident in an otherwise orderly scheme of things; can one be so bold and silly as to affront so much goodly opinion?

The Ninth Objection

Professor Laurence Henderson, in his book *The Fitness of the Environment,* set out to prove that the universe is biocentric, i. e., intent upon the origin and endurance of living things in general. The entire foundation of his argument may be stated in his own words:

"There is, in truth, not one chance in countless millions of millions that the many unique properties of carbon, hydrogen, and oxygen, and especially of their stable compounds water and carbonic acid, which chiefly make up the atmosphere of a new planet, should simultaneously occur in the three elements otherwise than through the operation of a natural law which somehow connects them together. There is no greater probability that these unique properties should be without due cause uniquely favorable to the organic mechanism. These are no mere accidents."

Two fallacies—it is argued—are to be found in this conclusion of Henderson. First, logic does not permit the assumption of a " natural law " which connects the properties together. Second, Henderson has here "ignored the context of chance as giving probability,"—that is, he forgets that:

"In the calculation of probabilities we make an assumption that several events are simultaneously possible. This assumption is an expression of two things: (1) our ignorance of the exact combination of factors leading to the coming event; and (2) the belief that in a series one combination will come up as often as another."*

The Tenth Objection

For all we know, the world in its entirety may be no more than the sport of Chance. In his classic work, *The Logic of Chance,* Venn says in regard to the possible production of the world by chance:

"We are not here dealing with figures the nature and use of which are within the fair powers of the understanding, however the imagination may break down in attempting to realize the smallest fraction of their full significance. The understanding itself is wandering out of its proper province, for the conditions of the problem cannot be assigned. When we draw letters out of a bag we know very well what we are doing, but what is really meant by producing a world by chance? By analogy of the former case, we may assume that some kind of agent is presupposed;—perhaps therefore the following supposition is less absurd than any other. Imagine some being, not a Creator but a sort of Demiurgus, who has had a quantity of materials put into his hands, and he assigns them their collocations and their laws of action, blindly and at haphazard: what are the odds that such a world as we actually experience should have been brought about in this way?

* Roy Wood Sellars, *Evolutionary Naturalism,* pp. 268-270.

"If it were worth while seriously to set about answering such a question, and if some one would furnish us with the number of the letters of such an alphabet, and the length of the word to be written with them, we could proceed to indicate the result. But so much as this may be surely affirmed about it; that, far from merely finding the length of this small volume insufficient for containing the figures in which the adverse odds would be given, all the paper which the world has hitherto produced would be used up before we had got far on our way in writing them."

Then, if we cannot even state the conditions of our problem, how can we figure the odds against the world (and man) being accidental phenomena?

The Eleventh Objection

Even if we are able to enumerate the factors in the world-equation as a step toward finding the probability of man's being created by accident, what system are we to use in calculating the probability? Poincaré, the eminent mathematician said: "The calculus of probabilities teaches us one thing at least, that we know nothing, for in this branch of mathematics, if we proceed far enough, we find that our ultimate results contradict the very hypotheses with which we commence and which form the foundation of our science."

Venn identifies the probability of an event with the relative frequency of its occurrence. Keynes objects that this objective viewpoint does not really explain what is meant by the probability of a unique event. Therefore he stresses the subjective viewpoint, leaving it mostly to our judgment-of-value to decide what is probable and what is not. Cohen thinks that the "probability of a given event properly varies as the evidence increases," and that "a probability is stronger if like a cable it consists of a number of independent strands." Cohen would therefore combine the objective and the subjective systems of ascertaining probability.

An astute critic of the efforts of the outstanding brains now engaged in the field of probability might well make this his opinion:

From the objective viewpoint, judging the probability of an event from the frequency of its occurrence, it would seem that there is no chance in countless millions of trials for two eminent theorists in the field of probability to agree upon the proper bases for their science.

From the subjective viewpoint, one's judgment of the past and present situations in the field of probability, is that there is no chance in countless millions for two eminent theorists in the field to agree upon the proper bases for their science.

Such being the circumstances in this branch of knowledge—or ignorance—how can we ever hope to formulate the one acceptable hypothesis concerning the probability of this creature, man, having been the infant of Fortuity?

The Twelfth Objection

Should it finally be shown that man, after all, is most probably not a chance phenomenon, how can we say that an event, no matter how improbable, is not possible? Even if there is only one chance in infinity that man is personified chance, still we can never be sure that this unique possibility has not been rendered actual.

The Thirteenth Objection

Even if man should finally be shown to be no accident, would he not still remain no more than a negligible incident, forever lost in a far vaster scheme? And one could scarcely choose between the terms negligible accident and negligible incident.

The answers to these thirteen objections would seem to constitute an impossible task—the more impossible that so many minds have been baffled before it. But the fact is that all of these objections may be traced to an undesirable though pre-eminent characteristic of modern scientific method and also—sadly—of modern thought.

They originate in an extreme narrowness of attitude. Broaden the outlook, consider the whole situation, and, miraculously, the objections are discovered to be illogical and fantastic. And a veritable miracle is required to shake the confidence of the teleophobes.

CHAPTER IV

The Foundations of Science

IT HAS been over three hundred years since Sir Francis Bacon emphasized the most important principles of the true scientific attitude. Is it time that our scientists rediscovered the value of Bacon's suggestions?

Of course Bacon did say that final causes (what I call narrow-minded conceptions of Divine purposes) are "but remoras and hindrances to stay and slug the ship from further sailing." And, indeed, he added: "Very meet it is therefore that we be sober-minded, and give to faith that only which is faith's." Yet nowhere did he object to giving to faith that which *is* faith's. Nor did he warn later (three-hundred-years-later) scientists not to study Greek and learn the true meaning of the terms which they, in combative ignorance, warn against. Thus, ask a scientist why he wants to steer clear of teleology in science. He will say that his objection arises from the unfortunate shortsightedness (of explanation) always hitherto associated with teleology, e. g., according to some theologians, teleology indicates that the *purpose* of the sun is to radiate light and warmth to man, and this "explanation" of the sun at once puts an end to further investigation and actually explains nothing.

As a matter of fact, does the word *teleology* connote *purposiveness*, or does it connote something else? Something which scientists unconsciously despise as much as they consciously despise what they assume the word to mean? Does *teleology* suggest *purpose*? Yes, says our scientist. No, says the more word-familiar etymologist. For, properly, the Greek term *teleion* is the source of *teleology* and means *complete*. The derivative of *telos*, meaning *end* or *purpose*, is, in all etymological exactitude, *telology*. Completeness is as much scorned as purposiveness, scientifically.

Three hundred years ago: "In general there is taken for the material of philosophy either a great deal out of a few things, or a very little out of many things; so that on both sides philosophy is based on too narrow a foundation of experiment and natural history, and decides on the authority of too few cases. . . ." And: "There is also another class of philosophers, who having bestowed much diligent and careful labor on a few experiments, have thence made bold to educe and construct systems; wrestling all other facts in a strange fashion to conformity therewith."

Today: The mechanist performs a few experiments, takes a look at the brain-mind, and asserts: "There you have a mechanism, complex indeed, but nevertheless a mechanism of no extraordinary type; complex indeed, but, after all, no grand consonance—instead, merely an air blown on the whistle of Fortuity." And the physicist and the chemist talk mouthings concerning the future explanation of this brain-mind in terms of the now-known laws of physics and chemistry. Does it matter that they, in their atom-titilating, have forgotten that our cosmos is a linked system? Let us see:

"Some of the main phenomena which an atom model is expected to represent and which have directed thought and speculation on the subject are:

Scattering of alpha and beta rays, and of X-rays, by matter.

The series spectra, both in the visible and invisible regions, including in this the X-ray spectra.

The phenomena of radioactivity.

The existence and properties of isotopes.

The non-existence of atoms of certain masses.

The periodic law, and associated periodic variations.

The laws of chemical valency and chemical combination.

A completely satisfactory atomic model, which is an unrealizable ideal, would of course have to account for all the observed phenomena of physics and chemistry, which are sciences of the atom. Many phenomena beyond those just enumerated have furnished helpful material for the criticism of atomic models. Crystal structure, magnetism, the viscosity of gases, the compressibility of crystals, the ionization of gases, and various other subjects of study in chemistry and physics will be cited as witnesses for or against certain views of atomic structure, and there is little doubt that with sufficient ingenuity almost any experiment can be made to furnish some evidence on so comprehensive a subject." *

One would assume that a scientist with that broad scope demanded by Bacon could for a moment at least harbor the bitter thought: A few hundred grams of brain stuff exhibit a unique co-operation of fourteen kinds of atoms—a co-operation so intricately harmonized, so complexly integrated, so stupendously smooth-functioning, so overwhelmingly vast in its achievements and potentialities, so closely knit from strands growing out of the innermost depths of the atom and out of the deepest abysms of creation's architecture, that ultimately the chemist and physicist must not only admit biology to be the most fundamental of the sciences, but must also, however unwillingly, even in their narrower theories take some account of how, in the very region of infinitesimals, there is promise of the boundlessness of the brain-mind.

Am I calling for omniscience? Definitely not. But I

* E. N. da C. Andrade, *The Structure of the Atom*. By permission of Harcourt, Brace and Co., publishers.

am asking why a physicist like Andrade—and there are few as good—why a physicist like Andrade, delighted by the very real beauty of the atom-system, cannot for a moment ponder the supreme height to which this atom-system can be raised—indeed can raise itself. Has no science-writer ever thought to leave a blank page just before summing up at the end of his book, this blank page signifying homage to wholesome, whole-minded modesty? Is there in truth no connection between the nice refinements of the atom's plan and the plan of the atom-plan's sublimest opus? It would not be in the slightest way unfair to point out that the connection is of such stupefying magnitude as to escape attention: who stops to wonder that he always has Infinity at his side? It would be unfair to common sense, however, not to point out that our physicists and chemists have no logical right to neglect man's brain in their necessarily limited researches and then to promulgate the idea that man's brain is an accident; that our physicists and chemists ignore the supreme integration of the phenomena which they necessarily divide into infinitesimal sections, and then sneer when one suggests that their deepest studies could, by some greater mind, be shown to point to a deepest-founded pattern whose central figure is the human brain-mind. I object not to ignorance, or lack of admission of ignorance, but to conceited jumping to conclusions, the spreading of false ideas, the cynical destruction of hope, and the dressing up of half-baked hypotheses as established facts—all of these activities being manifestations of ignorance and forgetfulness.

Three hundred years ago: "And there is yet a third class, consisting of those who out of faith and veneration mix their philosophy with theology and traditions; among whom the vanity of some has gone so far aside as to seek the origin of sciences among spirits and genii." Also: ". . . from this unwholesome mixture of things human and divine there arises not only a fantastic philosophy but also an heretical religion."

Today: "For mediums there are no secrets." "Miracles are scientifically established facts." "The phenomena of mental telepathy are scientific and yet transcend science." "You can be sure that when a clairvoyant reads your tea-leaves, she is earning her money."

Three hundred years ago: "Men become attached to certain particular sciences and speculations, either because they fancy themselves the authors and inventors thereof, or because they have bestowed the greatest pains upon them and become most habituated to them. But men of this kind, if they betake themselves to philosophy and contemplations of a general character, distort and color them in obedience to their former fancies."

Today: "The laws of chance enable us to predict accurately certain phenomena. Ergo, all scientifically established facts are but statistical concepts. Ergo, Nature is Chance. Man is a creature begotten of Chance."

Three hundred years ago: "There are some minds given to an extreme admiration of antiquity, others to an extreme love and appetite for novelty."

At the Scopes Trial: "The God behind evolution is a grander deity than the God of Special Creation." Now: " The God behind evolution is the dice-throwing deity, Chance."

Three hundred years ago: "The idols imposed by words on the understanding are of two kinds. They are either names of things which do not exist (for as there are things left unnamed through lack of observation, so likewise are there names which result from fantastic suppositions and to which nothing in reality corresponds), or they are names of things which exist, but yet confused and ill-defined, and hastily and irregularly derived from realities."

Today: "Man is an accident in a backwater of the universe." "The earth and earth-life are the results of the sport of Chance."

Murder in High Places

And thus, murder is being done in high places—murder of logic, of truth, of intellectual honesty, and of the fair name of Science. There are none, moreover, who have the scientific ability to protest, or who, being scientifically able, have courage to protest. The so-called logic of science has become so twisted as to squirm to a denial of the assumptions which form the very basis of science and from which all scientific judgments arise—but none seem bothered.

Nevertheless, it appears to me worthwhile to take note of the foundations of science which scientists themselves—incredibly—see fit to shatter and thereby to make uncertain their own edifice. The primal foundations to which I refer are four simple assumptions.

The First Assumption

The world as it is brought to our understanding through our senses (aided or unaided by mechanical devices) is real and has an objective existence, i. e., it has an existence apart from our minds. (The universe is not an unorganized realm of dreams and fancies.)

No evidence whatsoever has ever been brought forward to contradict this assumption of an objective world—unless we consider dreamy, hypnagogic hallucinations as evidence.

The Second Assumption

The world has meaning: it can be understood, if we make the necessary effort.

Can any one deny that Pasteur, Koch, Ross, Theobald Smith, Ehrlich, Noguchi, Carrel, Banting, and Goldberger have used this assumption to give us more of the meaning of disease? Even the modern Sceptic, sitting in his arm-chair, and distilling his over-refinements, cannot fail to perceive that armchair, over-refinement, distillation, and he himself would be non-entities had we no true understanding of pathology.

The Third Assumption

It is worthwhile to try to find this meaning. Otherwise, why trouble ourselves concerning it?

The Fourth Assumption

All phenomena are connected according to unchanging relationship. That is, the world is not a chaos, but a linked system of harmoniously integrated lesser systems.

This assumption amounts to an assumption of causality: That, given a certain frame of things (set-up), certain events are necessary, whether the time be past, present, or future.

Thus, the "law" of gravitation is an expression or description of certain relationships between things. The falling of an apple toward the earth is a particular instance of this "law" or "cause" or generalization describing within certain limits of accuracy a relationship necessarily holding true in Nature. The accuracy depends upon the efficiency with which common sense (understanding) has operated.

Science explains by giving us generalizations from which we can deduce particular instances and therefore enables us to make predictions—or to render explanation of what has occurred.

A corollary of this assumption is that when we cannot offer explanation of any phenomenon, we merely lack sufficient information.

These common-sense assumptions of science are denied any real validity by many philosophers, professional and amateur, primeval, ancient, medieval, and modern. Yet these derivatives of common sense, ignoring stupid metaphysical over-refinements of logic, have taught man how to predict an eclipse, to control disease, to lessen suffering, to give practical direction to the forces of

Nature, to use her substances, and in general to lift himself to a more dignified position in the universe.

There is additional, unanswerable evidence concerning the irreplaceable value and ultimate validity of these assumptions:

The historian of science, when asked for the event of chief significance in his field during the past several years, would unhesitatingly reply, "The whole recent development of science is a record of the destruction of the barriers formerly existing between the various realms of investigation." He would wholeheartedly agree with Pope, then, that

"The first Almighty Cause,
Acts not by partial but by general laws."

That is, granting that this historian believes in an Almighty Cause and would not prefer to paraphrase the poet by saying, "It is becoming increasingly evident that Nature is an integrated and harmonious system of systems." More convincingly than ever before, the universe not only can be described as a place of order, but also can be said to have a basic and unified plan.

But do not Heisenberg's uncertainty relations prove these assumptions false? Is it not apparently true that, under some conditions, the more precise your determination of the position of a particle, the less accurate is your determination of its velocity? In such cases it would seem that you are forever unable to predict the future path of the particle. Remaining ignorant of the motions of the particle, we apparently find the "law" of cause and effect breaking down. Would it not appear that, after all, the world is chaotic and meaningless? *

But is there nothing to be said for the corollary of our fourth assumption: that when we cannot offer explanation of any phenomenon, we merely lack sufficient information? When we cannot predict, we must believe merely that we are ignorant. It was once thought that the velocity of light could never be measured; that organic compounds could never be made in the laboratory; that the velocity with which a nerve-impulse passes along a nerve fiber was to remain forever non-measurable; and today these and countless similar thoughts have proven fallacious snap-judgments. Weak spirits, faint hearts—these scientists who are ever ready to kow-tow before the great Unknowable!

Ludwik Silberstein comments:

"Heisenberg's 'uncertainty' relation, even if its universal validity be granted, sets only an insurpassable limit to the simultaneous precision in observing the conjugate pair of magnitudes q and p, but, far from being,

* Either the world is a place of order or it is not. If it is in part chaotic, the world is not a place of order.

as he believes, a mortal blow to the Causality 'Law' or rather Maxim, it does not prevent us at all from attempting to construct for these and similar mathematical magnitudes themselves some determinate equations. It is quite true that, in the turmoil of hasty reform since 1925, no such strictly deterministic theory has been produced or is now in sight and that the olden scheme of causal space-time description of atomistic phenomena seems rather unequal to the task. But it would be rash and idle to deny the possible advent of such a theory, perhaps with the admission of an auxiliary fifth dimension, within the next decade." *

And, concerning indeterminism in radioactivity, he writes:

"There is nothing imperative or cogent about such an avowedly indeterministic attitude. It is ultimately nothing but the expression of a negative desire, of the unwillingness to delve deeper into the atoms and to hunt for their individual differences or, as it were, distinct 'marks' (before disintegration), an unwillingness strengthened, no doubt, by the absence of hope of ever actually discovering such differences and accomplishing a corresponding segregation of the atoms." *

It is always less a blow to man's pride to admit to the reality of miracles, a spirit-world, vital forces, principles of uncertainty, unpredictable aspects of Nature, and the like, than to keep repeating: "I, the great ex-

* Ludwik Silberstein, *Causality.* By permission of The Macmillan Company, publishers.

pert, am merely ignorant. A better man could resolve—will resolve—my difficulties."

On the whole, a fair judgment would be that the "glorious past" of Determinism justifies the hopes of those who have not yet surrendered in the midst of the thrilling search after a true understanding of Nature's mysteries. We do dwell in deep romantic chasms hollowed out of the unlit spaces of a savage-frowning creation—"a place as holy and enchanted as e'er beneath a waning moon was haunted by woman wailing for her demon-lover"—but to the true scientist the holiness, the enchantment, the waning moon, the haunting demons, the wailings—all have their explicable origins, and are Natural, not Supernatural.

May not the logic of the whole situation be expressed as follows? The universe is either an orderly system, or it is a chaos. If it is an orderly system, there is nothing chaotic (unpredictable) within it. If the universe is in part chaotic, it is essentially entirely a chaos. Admit the ultimate validity of the principle of indeterminacy, and you admit that we dwell in an incomprehensible realm of disorder. Thus, grant the inadequacy of any of the four assumptions given, and you deny the possibility of any science.

What Professor Conklin wrote in 1925 in "The

Direction of Human Evolution" is still worth remembering—and promises to be long worth remembering:

"The renewed interest in spirit manifestations which has spread over England and America since the war is, in many respects, similar to the belief in witchcraft which swept over different countries of Europe during the Middle Ages, and which lasted in some places well into the eighteenth century. Standing is given to such ignorant superstitions by a few intellectual and scientific sponsors, who can always be found for any novel or sensational belief, whether it be a denial of the laws of causality or of the value of scientific methods, a belief in perpetual motion, clairvoyance, ghosts, miracles, divine healers, or reincarnations. All such beliefs represent a protest against the slow and rational methods of arriving at truth by careful and repeated observations and experimentations, and a belief that by means of authority or inspiration, or occultism or mysticism, truth may be established more rapidly and successfully than by the slow methods of science." *

Carrel, who believes in miracles, and Jeans, Eddington, Haldane, Bertrand Russell—indeed all modern scientists and philosophers—who believe in the accident-theory of man's development—belong in the same class: that class of neo-scientists and neophilosophers whose statements, when carried to their logical limits, mean that no science is possible. For, a miracle is an accident

* E. G. Conklin, *The Direction of Human Evolution.* By permission of Charles Scribner's Sons, publishers.

and an accident a miracle: both terms defy definition. Further, both accident and miracle are beyond science.

Science which has not failed to keep in mind its first assumptions has shown steady progress. Metaphysics, which denies that common sense exists, has shown no progress. Science—or rather pseudo-science—which has been neglectful of its essential assumptions, has had a history similar to that of vitalism—ever a sort of negative progress: the constant development of new criticisms of the true and scientific judgments as these latter steadily move toward greater accuracy.

CHAPTER V

Beyond the Realm of Chance

It is a matter of common consent that science has shown, at least to the scientist's satisfaction, that the original production of human beings by chance is not merely a possible mode of origin of man but even the only probable one.

Again, it is almost universally agreed that there is such a thing as *chance* and that *accidents* do occur. But what do we mean by chance? What do we mean by accident?

Natural Selection

Casting about for the most sublime frolicking of "pure chance," few would hesitate to seize upon the sport of natural selection. What could better exemplify the haphazard gambolings, creative or non-creative, of Fortuity?

As the term, natural selection, was made famous by Darwin, perhaps I may be forgiven for a moment's glance at the workings of this scientist's brain. First of all, I would like to make it clear that no one but an unusually biased mind could for an instant think

Darwin did not establish, once and for all, the fact of evolution.

Next, it should also be evident to all, that Darwin substituted something for the crudely anthropomorphic conception of Special Creation.

Further, common sense plus experience must agree that Darwin correctly mirrored to us one of Nature's many aspects: over-production of offspring. Who can imagine fully the consequences, if generation after generation, each oyster produced 16,000,000 eggs, and each egg underwent the required growth and metamorphoses to reach maturity?

In addition, there is no doubt but that there is a struggle for existence. Lucky indeed is he who has not sensed the reality of this evolutionary factor.

And of course Darwin was right when he said that the fittest survive. Do not the unfit perish—the weak, the slow, the slow-witted, the diseased, the unadapted?

Finally, if the fit, amidst Nature's death-dealing manifestations, alone survive, who can gainsay the assertion: Natural selection weeds out the unfit, and therefore natural selection is a factor in evolution?

Therefore, I agree entirely with those who say that Darwin, though not original (no one is), made a very real contribution to the store-place of human thoughts.

So, I do maintain this: Darwin established, once and for all time, the fact of evolution—hinted at mutations—this much I admit. But beyond this I will not go in rendering tribute to a great mind. I shall maintain that, as much as he was an enlightener, so much was Darwin an obscurer. He substituted something for crude anthropomorphism and narrow ideas of Final Causes, but he himself was guilty of anthropomorphism as crude, and his ideas of Final Causes were as narrow. Moreover, he blessed ignorance with new names—names misleading and dry of thought-streams.

The theologian said: "Man is here because God put him here. How I know not."

The Darwinian says: "Man is here because evolution put him here. And evolution depends upon the play of Chance, in the guise of Natural Selection."

Over-production of offspring is very real. Struggle for existence is very real. In fact, you can read of these in the earliest religious works.

The fittest survive. True. But why? Because the ones which survive are the fittest. No biologist can say more. No religious work ever said less. "The meek shall inherit the earth." Why? They are the fittest: though perhaps not in a crude Darwinian sense. Darwin and the prophets both beg the question. It appears widely known that the prophets frequently beg the question. But Darwin—he is Authority! Could he beg the question? Of course not—but still he does: The fittest survive because those which survive are the fittest. Here we have an unsurpassed bit of word-coining, of ignorance hiding behind the skirts of a high-sounding new term, and of the murder of logic in high places.

Natural selection means that Nature steps in and plucks out of her garden of life those unfortunates which are not fit. Why are they not fit? Because the hand of Nature plucks them from their animate doings. More word-coining, more dressing-up of ignorance, more appeal to Final Causes as crude as a narrow conception of God, and more anthropomorphism.

For, what is Nature to Darwin or to the mutation-emphasizing DeVriesian? Chance. What is Chance? Chance is an image in the back of the minds of scientists—a mirage created by the twisting passage of truth through the hot-air of ignorance—some shadow-enshrouded giant sowing the seeds of things-that-came and the seeds of things-to-come. As we shall see, scientists have transferred their intellectual allegiance from a man-like god of order to a man-like god of whimsical, atom-scattering, life-pruning Chaos.

Some day, perhaps, we shall realize that we, being men, shall never be able to transcend some sort of anthropomorphism. Man will ever judge in man's own ways. The hope of escaping the pathetic fallacy of anthropomorphism is itself pathetic. Perhaps nothing is more pathetic than Darwin's substitution of a more crude, a more narrow anthropomorphism for that of the Special Creationist. And were Truth a deity, and had she to choose between Darwin and Milton, I think the world could do with the man, who blind, saw a greater panorama—though perhaps a less dynamic one—than did the seer with the sight.

The true question is not, How can we escape anthropomorphism, but What anthropomorphic view is the most honest, the clearest, and the most comprehensive photograph of objective reality?

Hence, I assert: Chance is a name for ignorance. Accident is a name for ignorance. Both are useful fictions when experience is sufficient only to give us a few factors upon which to proceed—as in gaming, where even the machinery of the game begs the question and establishes the "laws of probability" and the "play of chance"—and then only if we obey the rules of the game. Ignorance is not especially dangerous until it calls itself by some other name. And that name too often partakes of the nature of a Final Cause. For what is Natural Selection but a Final Cause, staying and slugging the ship from further sailing? And Chance, and Accident—these are the first-born of Ignorance and fit playmates of moronic half-developed conceptions of Final Causes.

Chance: A Fiction

The opinions of gamblers and of many modern scientists have a great deal in common. The gambler believes in the horseplay of the Supernatural—something which is fickle, is unscientific, successfully resists logical definition, and manifests its holy presence through a suspension of known relationships (causal sequences). As baffled men ever have, he digs up superstition when his brain is fagged and when there is seemingly little hope of making definite determinations.

The scientist is too often no clearer-minded. One calls for a spirit-world to explain what he guesses to be otherwise inexplicable. Another uses uncertainty to discover the certainty of free-will—and thus bounds, with a single spring, from the abysmal depths of atomic physics to the shaky heights of physiological psychology.

The general run of scientists use the fanciful and ignorance-concealing concept of chance to provide an "explanation" of the origin of man—the most stupendously complex organization of materials and forces.

Where readily verifiable truth seems lacking, gambler and scientist disinter the superstitions of the cave-man. Why not let the old bones rest a while? Or is that asking too much—for would not we by ostracism anger the ghouls whose flesh once clothed these ossified handiworks of Accident?

A coin will serve to illustrate the highest and the lowest concerning the "laws of probability." First, the game of coin-tossing is a man-conceived phenomenon. The "law" of chance in this connection is that, in the long run, as many heads as tails must appear. Why? It is the result of the man-created rules of the game. The gamblers agree: Let no man so toss that eventually the number of heads appearing does not approximately equal the number of tails.

May I bet that head will come up, then take the coin in my fingers and carefully place the tail-side flat against the floor? No. Why not? It is against the rules. I would in this way interfere with the play of intricate phenomena (chance).

May I by long practice learn the trick of deft manipulation and flip the coin with a neat twist which always yields heads? Of course not. Why? Again the rules forbid. Yet again: I *must* throw the coin so that heads and tails appear almost equally often.

May I not have the coin strike the wall or other obstacle and then the floor at such angles as will give only heads? No. The coin *must* be influenced so that—eventually—there is approximately a head for every tail.

Chance, at least in this case, is therefore definitely a fiction; it is the personification of intricate phenomena—which work so that a head shows as often as a tail.

Is chance always a fiction? In all games of chance, the probability is adjusted by the machinery of the game, i. e., the method of throwing, the methods of shuffling and dealing; the gambling equipment, and its mechanical make-up. The machinery of gambling begs the question: the probability is established before it is seen to work out according to prophecy.

Does not the coin have to obey the "laws of probability" as determined by mathematics? Mathematics cannot give us the probability without the aid of experience—and a knowledge of the "set-up." All mathematics can tell us about a coin-tossing event is, if the coin does not balance on edge, it may come head, or it may come tail—other things being equal, i. e., provided the coin is flipped so that we are ignorant of the spin, the forces, the angles, and the distances involved.

Cannot mathematics give us any idea of the odds against a coin's balancing on edge after a toss? No, because mathematics has nothing to go on—no experience, of a quantitative kind. We ourselves can say as much about the odds as any mathematician: the odds are very great. And that is all anybody knows. Common sense tells us that a coin is not very liable to balance on edge, because that is what we have learned from observation.

Cannot mathematics tell us the odds against throwing twenty heads in succession? Not unless we first assure the mathematician that we are going to throw the coin in such a way as to make sure it will not, in the long run, come heads much oftener or much less often than it will tails. Indeed, we ourselves in such a case and in all cases of probability for that matter, must first provide the mathematician with the information which he returns to us.

To illustrate: We ask the mathematician, What are the odds against twenty consecutive heads? In his turn, he asks of us, What is the nature of the game? We must tell him that it is such that if 20,000,000 men are tossing coins, almost precisely half will throw heads and the other half, tails. Then he proceeds to inform us—or rather to point out to us:

At the first toss: 10,000,000 toss heads (approximately)
Second toss: half of these coin-tossers throw 5,000,000 heads
Third toss: 2,500,000 heads (half of the 5,000,000 head-throwers throw heads a third consecutive time)
Fourth toss: half of those who have thrown heads three times running, toss heads for a fourth time

and continuing our halving process, we are shown that at the twentieth toss, approximately 19 will have had a run of twenty consecutive heads. Then, from these figures, which we have in all reality ourselves supplied to the mathematician, the mathematician estimates the probability of throwing twenty heads in a row, to be one in such and such a number of millions. He may not be precisely correct in his results, as they work out in practice. But that is not his fault, but ours—we did not tell him the truth when we said that 50% will throw heads. Of course it is that *approximately* 50% will throw heads.

Where does chance enter in? Chance is the name which we give to the numerous unknown factors which we use to make sure that one side of the coin will show about as often as the other. Did one of us know the value of all the factors which collectively we call Chance, then this one of us could always win—or until he was suspected of cheating.

Probability "laws" are therefore applicable only where, amidst individual disorder, an aggregate order prevails; and where the relative (though not the absolute) irregularities tend to diminish without limit and become negligible (i. e., where the greater the number of tosses—the longer the run—the closer to the average, say 50% in the case of heads or tails, the events occur).

Is chance always a fiction? Yes—emphatically. When we state that a phenomenon is the product of chance, we do not, cannot, deny that there are determining factors (definite causes) at work; we mean merely that the causes are complex and temporarily beyond detailed analysis.

If the scientist would only admit to the grossest ignorance—if he would not name ignorance *Chance*—if he would do a little clear thinking and realize that to personify chance is grosser anthropomorphism than to appeal to a God of Special Creation—if he would only realize that the "laws" of probability are man-made, hypotheses of very limited practical value—if he would admit that it is intellectually dishonest to ascribe to

Fortuity, a lesser deity having no real existence, what was formerly ascribed to a Grander Something—if he would only realize that statistical knowledge is not the whole of science and had nothing to do with the discovery of the tuberculosis bacillus—if he would puncture conceit and in deflated modesty find he has been too ready to tell pretty stories, full of nice, new fairies, rather than to enlarge upon the old, old tale, full of tiresome though wholesome unknowns—then we might be sure faith would regain a particle of what is faith's.

Ludwik Silberstein is one scientist who does not fear to let it be bruited about that he does not have omniscience:

"The attitude of bare probabilities and indeterminacy, a comfortable lazy one, can in the best of cases be considered as temporary and provisionary, as something equivalent, in fact, to a veiled confession of man's ignorance of a host of possible details."

And, in the same work, *Causality*, he says:

"It is hard to refuse oneself in this situation [involving the "spontaneous" or "chance" breaking up of atoms in radioactivity] a parable, even a coarsely anthropomorphic one. For such parables are often useful. Imagine, then, a thousand male slaves placed by their master on some island and through their steady toil producing for him cotton or maize, or what not. They are picked so as to be, like the radium atoms perceptibly equal in all relevant respects, from the master's angle of course: same weight (mass), same height and chest, same strength and efficiency. This being granted, let their 'mortality' or annual death-rate be invariable and as high as 0.040. (The death-rate in England and Wales for 1876 touched 0.021, and fifty years later dropped a little below 0.012.) This means that our master will lose in the first year of his enterprise 40, in the second year about 38 men, and so on, with the familiar probable errors. Being a good business-man and an equally heartless slave-driver, the master will not evince the slightest interest as to the individuality of the 'souls' who thus drop out inexorably from his working phalanx. Whether it is Paul or Peter who dies within the year is utterly indifferent to him. The only relevant thing about their passing away, which in fact must be carefully weighed in his commercial plans, is that death-rate itself, the numerical value of the 'probability' of *any* slave to die within a year. Our cotton planter, being neither a naturalist thirsting for the natural history of biped mammals, nor a sentimentalist, will be far from feeling pledged to the deterministic principle (with regard to individuals) which for his business in hand is certainly deprived of all heuristic, lucrative virtue. He will be content to adopt the exceedingly practical scheme of probabilities and statistics.

"Suppose, however, that this blessed island is visited by a traveller who happens to know a good deal of medicine and hygiene, and carries also in his breast a keenly and sympathetic interest in the life of humans, not just as a mass or a social group, but individually. Such a visitor will soon discover a number of specific differences between the slaves yet surviving at the time being and in the conditions of their environment, and will be able to single out if not all, but at least some of those who are pretty sure to die within the year. Nay, if some are stricken by an infective disease, he can even render a practical service to our planter, namely by isolating them, in housing and intercourse, from the remaining ones and thus reducing the death-rate of the whole phalanx of workers. In fine, he will be far from accepting the summary, indeterministic attitude of the planter, he will find Determinism delightful and valuable as well. The simple reason is that his knowledge of and interest in the individual goes much deeper than that of the master, the planter." *

Surely, those who believe in the reality of chance have been seduced by the blissfulness of ignorance.

Accident: An Inconceivable

When a train runs into a bus which has been stalled on the tracks, and forty persons are killed and a hundred are injured, this occurrence is described as an accident. When a star wanders near our sun in its youth, as required by the Chamberlin-Moulton theory of the origin of our solar system, and the resultant tides ultimately give rise to planets, this event is regarded as accidental.

When we use the term *accident,* as in these two illustrations, we vaguely feel that the happening might well

* Ludwik Silberstein, *Causality.* By permission of The Macmillan Company, publishers.

not have taken place: something went "wrong." Vaguely we and the scientists feel the Presence—of Fortuity, whose fingers seem to do so much poking around in this existence of ours. The *accident* represents the fickleness of Fate, and amounts to a meaningless, sometimes tragically meaningless, incident.

Yet inquiries are launched to sail about over the sea of our ignorance, with the hope of discovering at least the outlying islets if not the whole continent of Causes. The "explanation" of the accidental train-wreck may or may not be forthcoming. Nevertheless the guess is made that "something lies behind." If such and such had not been the antecedents, the accident would not have been the consequence.

Thus, in the case of the train-wreck, we anthropomorphize and call our ignorance by the name of Accident (begotten of Chance) on the one hand, and then, on the other hand, common sense dictates that causeless or *purely fortuitous* events do not occur, and we start an inquiry. As we shall see, it is the attempt to conceive of *pure fortuity* or *unrelated, parthenogenetic Chance,* that makes for an abortive anthropomorphism.

The approach of two suns may be termed an accident, for this terminology is more graceful than the language of ignorance. But does any one have any doubt that the primal nature of our universe was a necessary antecedent to the movement of a star into the vicinity of our sun, provided of course that the Chamberlin-Moulton theory is true?* And the term accident might be forgiven its crude anthropomorphism and its deceit were it not that it is confusing, since meaningless.

To show the absence of meaning from such an idea as that of accident: The word *accident* connotes, as stated, that the event to which it refers could have conceivably not happened at all. In the instance of the train-wreck, we may say: if the bus had not been there, if the bus had not stalled, if the gasoline in the tank of the bus had not given out suddenly, if the tank had not developed a tragic leak, if the alloy of which the tank was made had not been susceptible to rust, if the tank had been inspected, if the maker of the tank had used a different alloy, if the tank-maker's experts had suggested a different line of research in alloy-composition, if the nature of metals were such as not to undergo electrolytical decomposition, if the constitution and evolution of the cosmos had been along more friendly lines,—in short, if man had omniscience, he could not only fore-

* Concerning the birth of our planetary system, the encounter theories now dominate the field—but the fact is that no satisfactory theory of the origin of the solar system has been developed. Its origin is really unknown.

stall any potential happening (accident) but also he could conceive of how the universe might have been taken apart in toto, put back together, and made to tick differently—and the bus would not have been in the path of the speeding train. Any event which has taken place, whether we call it accident or whether we call it the course of Nature, could not conceivably have been altered in the least. When we speak of accident, and think of a possible alternative to the accident, we are indulging in superficial thinking. Omniscience would be required to describe how any alternative could be rendered real. The term *accident* is as meaningless as infinity, because it presupposes infinite understanding.

Bertrand Russell is noted for his pioneer work in the fusion of mathematics and symbolic logic. In the words of Roy Wood Sellars, who is referring to the development of Realism in modern philosophy:

"Bertrand Russell has probably been the most conspicuous figure of the English movement. He owes his prominence to various factors among which we may mention his pioneer work in the fusion of mathematics and logic. It would, I think, be generally granted that his contributions to symbolic logic were marked by careful scholarship and ripe reflection."*

* D. S. Robinson, *Anthology of Recent Philosophy.* By permission of the Thomas Y. Crowell Company, publishers.

So, when Mr. Russell points out that "man as an accident in a backwater" is conceivable, it must be that he has kept secret from us some new development of his in mathematics and symbolic logic (now a branch of mathematics) whereby an accident becomes logically and mathematically conceivable. For up to now, mathematicians have despised accidents in their work, and have claimed that, except where born of minor human error, factors do not appear fortuitously and thus out of nowhere. I suppose that now at last we must resign ourselves to, and the schoolboy rejoice himself in the truth that what is human error in a lower branch of mathematics becomes a necessary factor in some higher branch. A figure pops into the equation and renders itself into inky reality; immediately it is seen to move amidst the other but reason-harmonized symbols, shifting them, shoving them right and left, up and down; all is solved, resolved, and dissolved within a fraction of an instant. Inquire of your neo-mathematician, Whence this little inky disturber and what his value? He replies, A child of intuition, and a true representative of the gyrations of accidental phenomena.

Experience, Common Sense, and Communism

In one case, however, Bertrand Russell's opinion is worthwhile:

"The rise of new religions in Russia and Germany, equipped with new means of missionary activity provided by science has again put the issue of the persecution of those who seek to promulgate truth in doubt, as it was at the beginning of the scientific epoch."

Russell does not realize that, deifying Fortuity, he is also deifying communism. For communism, as it is mouthed today, has allied itself for no scientific or religious—or even practical—good with that weirdest of all vagaries of the human mentality: atheism. Militant atheism, as it is practiced by our numerous pseudo-communists, would stifle any scientific view which gives an anthropocentric interpretation of the cosmos. This is a practical, hard-boiled creation, this civilization of ours, and one who would see truth gain its due must even be political minded. Some difficult-to-explain fancy has united the broadest sweep of the fallacious, pseudo-communistic theories in all history, with the most disastrous misinterpretation of man's significance to the universe. The accident-theory of man's Becoming yields its wide dominance to another still stranger power: atheistic pseudo-communism.

Moreover, we who are eager to forestall any possible twentieth-century dive into the tenth-century sea of Ignorance, Prejudice, and Superstition may be forgiven for becoming voluble at the least suggestion of gullibility on the part of those at whom Dogma and Narrow-mindedness are so loudly shouting. Now, in fact, suggestion has turned into definite proof.

We have emphasized the failure of the "laws" of probability where experience is not available. A discussion of probability can also serve to bring out that which has failed to impress modern science and the communist: that man is after all, though a machine in one sense, a machine complex beyond imagination. For, from the infinite phenomena of the universe has been molded a new infinity—the potentialities of the human mind.

The scheme of a life-insurance or fire-insurance company is based upon experience and upon the play of a limited number of pretty well-known factors. The scheme of a national and omni-inclusive insurance company—a communistic society—is based upon the false idea that every man is the average man. Common sense, the "laws" of probability, and our past experience of man suggest perhaps the most cogent argument against nation-wide regimentation, or communism. The communist, too vaguely grasping the rules for making averages, mistakenly assumes the reality of what is clearly a non-existent, ethereal ideal—the *average* individual amongst a group, each member of which is characterized by a stupendous complexity of qualities—talents, longings, hopes, fears, ambitions, energies, instincts, loves, and faiths—whose number and variations closely approach, if they do not actually reach, the infinite. For instance, the variation in human mentality and personality is so great that one man alone can by new hope overwhelm an age.

So the communist would emphasize this side of the logic of chance: *notwithstanding the individual disorder, an aggregate order prevails.* Thus, as is well known to the logician and to the life insurance companies, the irregularity of the particular instances diminishes when we take a large number, and finally seems to disappear *for all practical purposes,* as in the case of the minor considerations of life. Betting on one factor, as do the life insurance companies in the case of the average expectation of life, is safe enough in the long run, especially since the expectation of life is fairly well governed by fairly well-known laws.

But the communist would forget this other and readily demonstrable side of the logic of chance: *it is not the absolute but merely the relative irregularities which thus tend to diminish without limit and become negligible.* Little variation is possible in the instance of the length of life. Unlimited variation is the rule in human personality. The *absolute* variation in the length of life, that is, the difference between the ages at which it is possible to die, is almost never more than a hundred years. These absolute variations sink into relative insignificance beside the vast numbers of particular instances which "obey" the "law" of averages and which establish the general or average expectation of life. On the other hand, suppose that twenty million men are tossing coins. The greater the number of tosses, the greater the chance for extraordinary runs of luck to occur. Thus runs experience. It would be certain that some would, in the course of events, obtain heads (or tails) a thousand times running. In fact, no limit can be set on the absolute difference between the minimum run of luck—one head—and the maximum, potentially an infinite number. So it is, as we know, with the personalities of men—whose psychic characteristics, far from being constant, fixed, or even in the least respect susceptible to averaging, are boundlessly variable. In ways too numerous to grasp, the absolute divergences and irregularities of mankind show a disposition to increase without limit as human population increases—and especially as civilization, the great stimulator of illimitable mentality, makes progress.

Therefore, true regimentation there can never be: the impossibility of "hedging" against all human risks and achievements is a fact, not a theory. The human race has been on the earth a million years. In all this time, no civilization, aboriginal, modern, or pseudo-modernistic, has been devised which can so well permit the limitless play of instinct, emotion, and reason as can a modified capitalistic society—modified ever lest the on-press of always increasing complications crush the unfortunates whom we have enduringly with us. Even Russian pseudo-communism finally takes official cognizance of the fact that men, born of earth, have liking for things of earth, including freedom, and becomes still less like the unrealizable ideal of those who would insure all departments of human endeavor, would thereby give the ownership of all things to each man, and thereby also make each man the property of all men.

Hence, faith in the practicability of communism rests upon the faith in the reality of the average man, who is non-existent.

Philosophical Speculations

To a greater or a lesser extent, we tend in betting fashion to accept the speculations of philosophers as demonstrable truths. Yet any cynicism—such as that of Bertrand Russell's—so engendered within us has no logical basis. The philosopher is a poor gambler. He speaks generalities concerning mankind's joys and sorrows. But human emotions are non-measurable and non-estimable quantities. Where calculation is impossible, no average can be struck. How can the philosopher reach justifiable conclusions concerning the psychic side of man, when the only logical way for him to reach them is by striking an impossible average?

In Defense of Henderson

In his *Fitness of the Environment,* as we have seen, Henderson stated:

> "There is, in truth, not one chance in countless millions of millions that the many unique properties of carbon, hydrogen, and oxygen, and especially their stable compounds water and carbonic acid, which chiefly make up the atmosphere of a new planet, should simultaneously occur in the three elements otherwise than through the operation of a natural law which somehow connects them together. There is no greater probability that these unique properties should be without due cause uniquely favorable to the organic mechanism. These are no mere accidents."

Taking the last point first, we can, as we have seen, be sure that "these are no mere accidents," for the very simple reason that the concept of accident is entirely fictional. There is no such thing as an accident.

Now, it is true, and I will freely admit that it is true: there are such things as coincidences, i. e., superficially related phenomena. Therefore, it remains for us to perceive in the case of one coincidence or a whole series of apparently related coincidences, whether the association in space-time is superficial or whether it is necessary. To show that the two elements in a coincidence are causally related (by a fundamental relationship holding throughout the universe), it is required to prove that the strands uniting the two elements arise out of the bedrock of the cosmos. In a later section of this volume we shall see that what Henderson terms "no mere accidents" are actually deeply related (i. e., causally related) events.

Furthermore, where Henderson speaks of "chance" and "probability" he is using the language of science in a common-sense way. Where there are too many coincidences, there science has never failed to find a causal relationship. Why not here? So many seemingly superficially associated phenomena rise above what common sense would call merely evanescent, unconnected relationship. Finally, a natural "law" is a causal relationship—whether or not one wants to go about calling it "scholastic" or some other derogatory name.

If Henderson, using understandable language, has "ignored the context of probability," his critics have ignored the fact that chance is a mere figure of speech, the fact that there is no accident in this our linked system of order, and the fact that a series of innumerable apparent coincidences has ever pointed out the way toward a causal relationship as deep as the depths of the Milky Way.

Of this we shall see more in a later chapter.

Behind the Veils

What really stands behind the veils of the One which we call Nature? No man can say. Many and great are his efforts to say. And still the earth wheels on far into the black gulf of time, a little glowing spheroid in a mighty cosmos, carrying its billions of men and trillions of other living forms on the greatest and most thrilling of journeys. Some say it is an everlasting voyage from the unknown into the unknown. And the blazing sun, dragging after it the nine planets, one the abode of life, rushes forward to a secret destination, which it will not reach until all its radiance is gone, and wondering man has vanished from the frozen, silent earth, at last the dwelling-place only of death. Yet—would the bolder among men entirely agree? May not man, unaided by the intervention of Providence, at some far off moment, somehow attain intellectual strength sufficient to rieve the last of the seemingly endless series of wizardwoven, elusively flitting veils that are between our eyes and the Great Enigma?

The question remains unanswered. But this much we can affirm: the Great Enigma has no veil which man can aptly call *chance.* Nature, including her natural offspring, man, is beyond the wraith-haunted, elf-vexed, fictional caverns of Chaos, and beyond the realm of Chance.

Therefore, when we seek to penetrate the mists darkening life's and man's actual genesis; when we try to put our surmises into words; when we develop in our minds a picture of black storm-clouds gathering in the heavens of the late afternoon of a long, sultry day; lightning flashes preceding the thunder, which echoes back and forth from the dead hills cradling a brackish lake; when we envision an incandescent bolt, all at once darting in a zig-zag path through the wind-gusts to plunge headlong into the slime lapping at the lakeshore; when we sense who-can-say-what tremendous disruptions and syntheses of molecules, and the indescribable writhings of the first earth-creature, born amidst the gloom cast by angry skies, and almost annihilated at birth by the torrential downpour; and when we, crudely anthropomorphizing, fancy that this little protoplasmic particle, the ancestor of all animate beings, in some strange mode, guessed its future, its myriad descendants, and the fears and hopes of thirty trillion humans—and when we marvel at what lay behind all this, then we can be sure of one thing at least—if only one thing—there was a Plan, bred of Harmony—not Accident, bred of Chaos.

CHAPTER VI

The Mystery of the Life Elements

THE LIFE material, protoplasm, is built up from certain of the ninety-two elements with which chemists deal. Any element essential at least to some form of life is a life element, or bioelement. There are, so far as can be ascertained in the present phase of biochemistry, twenty life elements, as follows:

HYDROGEN	CHLORINE
BORON	POTASSIUM
CARBON	CALCIUM
NITROGEN	VANADIUM
OXYGEN	MANGANESE
SODIUM	IRON
MAGNESIUM	COPPER
SILICON	BROMINE
PHOSPHORUS	STRONTIUM
SULFUR	IODINE

Fluorine is usually included in lists of the essential elements, but a careful weighing of the literature would suggest that it is not demonstrably essential to any form yet investigated. Silicon is accepted as a life element because of its undoubted importance to diatoms (the "grass of the sea") in their natural habitat (and not because it constitutes so large a portion of the ash of many higher plants, to which, upon a basis of the experimental results obtained by many investigators, it would appear non-essential). Strontium, seldom mentioned in the literature of biochemistry as a life element, is also to be accepted as a true bioelement, because of its functions among the Acantharia, which are marine protozoa with transparent shells of acanthin, a glass-like variety of strontium sulfate, and because it seems impossible that these forms could, in their natural habitat, survive without it.

Of course this list of bioelements is not to be regarded as complete, especially in view of the recent discovery that some higher plants need boron. Furthermore, many competent investigators claim that aluminum is essential to certain plants, that zinc is needed by some fungi for sporulation, that titanium replaces iron, that nickel is required by mammals—in fact, there seems to be many a good claim worthy of careful consideration. But I believe that this list of twenty bioelements is as complete as possible upon a basis of what is well established.*

* Certain microörganisms apparently have the ability to use compounds of arsenic, selenium, and tellurium, as sources of energy. But these elements are non-essential in such cases, and do not enter into the composition of the microorganism.

Not all protoplasm requires all of these elements. Indeed, only nine of them are essential to every organic form: hydrogen, carbon, oxygen, nitrogen, magnesium, phosphorus, sulfur, potassium, and iron being this fundamental complex of bioelements without which no variety of protoplasm can exist. The other bioelements are required in varying numbers by the various living creatures. No form is known which requires them all. Man must have fourteen—so far as we are now aware.

The Fundamental Biocomplex

The group of nine bioelements, just named, constitutes the foundation for all the manifold structures of living things, and the basic materials for all vital processes. And the researches of plant and animal biochemistry prove that under no circumstances whatsoever can another element be substituted for one of these nine, and the organism survive. So well established is this fact that we can use it in making a satisfactory definition of life:

> A living thing is an organization which exhibits metabolism (respiration, digestion, assimilation, sensitivity, memory, reproduction, etc.) and whose basis of structure and function is this group of nine bioelements, occurring in definite proportions.

Throughout the literature of science and popular science we find the assertion that there is no definition for life which is satisfactory. Why has no clear definition been possible? It is because biologists have failed to realize the uniqueness of the elements which constitute life, and that life is essentially nine elements, in definite proportions, and organized so as to carry on a definite and integrated system of activities. These nine elements stand alone in all infinity as elements able to form the basis for life.

The Uniqueness of the Basic Nine

Contemplating carbon and its myriad pregnant affinities, we can almost feel the play of unguessed forces at work. The four bonds it offers seem like inconceivably fragile and tender little hands ever groping, ever seeking to grasp other hands and form first those infinitesimal links and then those chains of fairy-magic out of which the perishable living fabric is so finely woven. By its unequalled ability to produce stable compounds of the greatest complexity, carbon is the source of the largest portion of the complexity, plasticity, variability, and individuality essential to the materials which can give rise to living organisms. "The position of carbon, standing as it does between positive and negative elements, invests it with a peculiar capacity for uniting with the most different elements, as hydrogen, nitrogen, oxygen, chlorine, etc. To this is due the property of adapting itself alternately to the processes of oxidation and reduction, which have such significance in animal and plant life." "A chemist would immediately put his finger on the element carbon as that which is needed to endow an organic substance with complexity of form and function, and its selection in the origin of plant life was by no means fortuitous." The same holds true of carbon in relation to animal life, and to those very low types of organisms intermediate between the plant and animal kingdoms.

Hydrogen, like carbon, in an unparalleled manner, exhibits properties which fit it as no other element to play a whole group of highly varied roles in the protoplasmic mechanism. Its atoms are the most minute, the most mobile, the lightest, and have in the highest degree those chemical attributes which enable it to co-operate with the other elements in producing life. Perhaps most important of all its activities is its union with oxygen to form that most singular of all substances, water—the great medium for and stimulator of reactions, the great solvent, and the great dielectric. And, in the words of Osborn, "As a reservoir of life energy which is liberated by oxidation, hydrogen exceeds any other element in the heat it yields, namely, 34.5 calories per gram, while carbon yields 8.1 calories per gram." It is a constituent of all organic compounds which are in any way utilized by protoplasm. It gives rise to hydrogen ions, which make possible, cause, and regulate an immense number of reactions, and which aid in the production of bioelectric currents. It is a part of the hydroxyl ion, whose importance is similar to and as great as that of the hydrogen ion. Hydrogen and sulfur form the highly reactive SH group, so valuable in many of the most delicate and essential reactions of life chemistry. And finally, hydrogen plays an irreplaceable part in the formation and activities of certain vitally necessary inorganic compounds, such as acid and basic salts, including bicarbonates and acid phosphates. Given carbon as the keystone of cell metabolism, no element can aid as hydrogen does in creating the basis for life phenomena, even unto memory, instinct, intelligence, devotion, and happiness.

Oxygen, besides being a constituent of "the most complex of problems"—water, the compound of first importance to life—acts as the chief intermediary through which energy is made available to the living substance; is a component of almost all substances which enter into the protoplasmic economy—both organic and inorganic compounds alike; and with hydrogen, gives rise to the hydroxyl ion, thereby making possible the practically infinitely ramified system of acid and alkali activities. Crile states, further: "It would appear that water and oxygen in a vital and inseparable relationship are essential to the production of the electrical variations within the cells, the manifestations of which, as it would appear, constitute life." Lastly, in the case of another vital and inseparable relationship, with carbon, oxygen is seen to provide both a means to the formation of the food supply of practically the entire living world, and a means to the utilization of this food. Following the cycle of carbon dioxide in nature opens our eyes to a vast system of organic processes and interdependences totally impossible with any other two elements, and completely unique chemically and physically. Thus, again, we have an element manifesting a set of characteristics which cannot be duplicated by any of the other ninety-one: and each characteristic is as necessary to life in the large as the sun to rain.

Nitrogen has as distinctive a personality as carbon. If carbon is the staid and conservative banker, the backbone of the nation, nitrogen is the explosive-natured entrepreneur, just as essential to progress. The carbonaceous portion of the life material gives rise to the necessary stability; the nitrogenous portion, to the required instability. In general, it may be accurately said that the metabolism of nitrogen, characterized by supreme delicacy of reaction, serves at once to offset and permit the utilization of the relatively much cruder reactivity of the majority of carbon compounds. Nitrogen endows the proteins, the most significant class of vital compounds, with peculiar and important properties. The extreme reactivity and sensitivity of proteins, and a host of other physical and chemical properties, such as typical solubilities, osmotic pressures, degrees of dissociation, and colloidal attributes, are in great degree dependent upon the possession of this element. In the formation of proteins in plants, probably carbohydrates are altered and, with nitrogen obtained from the atmosphere or from ammonia, ammonium salts, nitrates, and nitrites (depending upon the plant), are caused to give rise to amino acids. These acids then are linked to form more and more complex peptides, the most complex of which are the proteins. The amino-acid permutations and combinations possible because of the linkage of these acids in the formation of proteins, produce the unlimited variety and specificity of animal and plant life. Because of the presence of nitrogen, proteins are able to react sometimes as acids and sometimes as bases. No chemist can suggest another element capable of fulfilling the manifold difficult duties so satisfactorily assumed by nitrogen.

Nor can any form of life do without sulfur, needed as a component of proteins and of the irreplaceable, labile sulfhydryl group (SH). Once more we can be sure that we are dealing with an element which has, in unique fashion, qualities that render it suitable for the origin and development of life.

Concerning phosphorus, enough has been brought to light for it to be termed the "controlling element." Its peculiar group of properties and reactions, superimposed upon the system made up of carbon, hydrogen, oxygen, nitrogen, and sulfur, bring a new order of things. This element plays an active part, and an indispensable one, in the nucleus, which is the center of control of the general cell processes and the center of control of heredity. In addition, upon phosphorus is dependent nerve-and brain-cell functioning. So phosphorus can be pictured as offering the gifts of growth, reproduction, and extreme irritability (sensitivity), and regulation of these marvelous faculties, to the five elements already conspiring to generate the organic from the inorganic. And these functions of phosphorus have not by any means exhausted its vital possibilities. Without it, fats cannot be assimilated. As phosphates of sodium and potassium, it aids in the maintenance of the neutrality of vital fluids. Shell, teeth, and bone-formation cannot occur where it is lacking. Finally, an entire new biochemistry is being worked out around a group of phosphorus-containing compounds which seem to have possibilities as unlimited, as sensitive, and as specific as in the instance of the proteins—though possibilities not to be realized without the aid of proteins. These compounds are the phosphatides or phospholipides, which are closely involved in such momentous processes as contractility, the manufacture of foods of every kind, in respiration, and in the higher mental activities. The flesh of man is the green meadow-grass transformed; the grass-pigment is suspended in phospholipides that must be present for the plant to make sugar and starch from air, rain, and sunlight.

The metaphysician has frequently essayed to conceive of thought as a sort of phosphorescence playing around the dancing molecules of the cerebral cortex. Today we can perceive that he was nearer actual truth than even he himself hoped—though not precisely in the direction in which he was making his search.

So, all in all, phosphorus stands out unchallenged in the extent and number of properties which fit it for the host of roles that it must play in order that life may *be.*

Like the other bioelements, it is provided with just those facets enabling it to slip into that niche in the complex of life which would otherwise be empty, and the cosmos empty of the slime-mold and the Wagner.

Now, potassium is concerned with certain fundamental conditions within protoplasm. It has been suggested that so basic and important a process as respiration is directly dependent upon it. Certain it is that neither respiration nor any other vital activity can occur where potassium is unavailable.

It is the only radioactive element of which the life material makes use. The meaning of this fact is unknown, although the feeble radiation from this element indubitably has its effect upon the life-forming substances. In plants, without potassium no starch is produced. In protoplasm in general, it is necessary as a regulator, its salts balancing the effects of other salts, and often acting as stimulating agents, as upon the brain and sensory nerves. Confirming the specificity of its role, potassium is lacking in the cell nucleus and in the cell wall; and no element can be substituted for it in the cell economy as a whole.

Magnesium too has its individuality, chemically, physically, and biochemically speaking. The soothing green of the leaf is chlorophyll—no magnesium, no chlorophyll: many a secret of the plant and of life is locked within this compound built around this element. An irreplaceable part of blood, bone, teeth, muscle, and nerve; a carrier of phosphates; a stimulator of reactions; an agent in complex physiological syntheses; a neutralizer of toxic concentrations of salts; an adjustor of intricate reactions calling for very finely balanced conditions; an assistant at the birth of oils—these are some of the known uses to which magnesium is put, and to which magnesium alone of the ninety-two elements can be put. Indeed, no protoplasm and no portion of protoplasm can get along without it. Once again we have come upon an elementary substance which biologically has no like. Therefore it has no like within the bounds of creation entire.

The lowly fungus that rots our bread; the towering Sequoia, whose branches have stetched toward the sun for thirty centuries; the new-born rat, and the leathery patriarch—all these, and all life, are iron-hungry things. Iron, the ninth on our list of the nine fundamental bio-elements, fits into the complex as an agent in biological oxidations—the sole source of energy for the vital machine. This much is sure concerning iron. And this much is also sure: for iron there is no substitute, as far as the basic factors of physiology are concerned. (Those animals which make use of copper, vanadium, or manganese instead of iron as the metallic portion of their blood color-substances, at the same time have an iron-containing respiratory compound in their tissues.) A number of elements, such as nickel and cobalt, remind the chemist of iron. But such is the singular delicacy of protoplasmic activity that, wherein iron is of service in the basic life processes, no other element can be of any use whatsoever, however closely the element may chemically resemble iron. Still again we are forced to conclude that any slightest variation in those properties which give an element a place among the fundamental bioelements would be great enough to destroy the whole organization of the living material.

So, in this brief survey of what biochemistry has in recent years disclosed regarding the basic materials for life, we learn that a host of interlocking fitnesses of the elements composing plants and animals is a prerequisite to vital phenomena. We find that certain elements, and no others, no matter how closely related to the bioelements have separately and in conjunction, that remarkably specific pattern of attributes which adapt them to make protoplasm, the life material.

There are, then, in the nine basic bioelements, special possibilities which other elements cannot offer. Henderson, after an eminently logical and fairly exhaustive discussion of the relation of the three elements, carbon, hydrogen, and oxygen to life, points out:

"In general chemical behavior, in certain special characteristics as well, and in the magnitude of the quantity of energy rendered available by their chemical changes, the elements carbon, hydrogen, and oxygen are uniquely and most highly fitted to be the stuff of which life is formed and of the environment in which it exists."

The progress of biochemistry and biophysics has now reached such a phase that we are enabled to make a deep, comparative study of the elements which enter into the composition of the organism, and to determine that what Henderson proves concerning the uniqueness of carbon, hydrogen, and oxygen, can be extended to the other six elements of our fundamental biocomplex. Today it is distinctly clear that the type of systems within systems which means life, could not be constructed with any other elements than the nine basic bioelements as the foundation.

Beyond this, we can remember that the environment is as much a part of the living thing as man's heart is a part of him, we can recall that life is characteristic only of highly specific organizations of highly specific elements co-functioning amidst highly specific arrangements of energy and amidst highly specific configurations of celestial bodies, and then we can, having such considerations in mind, summon to our understanding the old and recent discoveries of physics, geology, and astronomy, as well as of chemistry. Finally, considering the gigantic subject of energy in its relation to the life elements and to life; considering the nature of the environment that necessarily must be one with life; considering the life-web whose entirety permits, as no substitute can, the particular species, as microbe and man; scanning the potentialities of the heavens; and at last weighing again our conclusions regarding the uniqueness of the life elements, it is more than intellectually exciting to grasp that nowhere in the wide reaches of the cosmos can there be other elementary substances which can show the same action, reaction, and interaction, and so become integrated into a living mechanism.

Physics and the Life Elements

Physics and biophysics combine to emphasize the peculiar natures of the nine elements of the basic biocomplex. Electrons, protons, neutrons, and deuterons being what they are; the forces characteristic of universal space being what they are; the attributes of protoplasm being what they are; the human mind cannot conceive of a frame into which life would fit save it be the frame whose main mass is made of our nine. Unless one of us has omniscience and the power to shatter this world, in his imagination, and to start from nowhere and no-time, to design, infinitely potential step after infinitely potential step, a dissimilar but life-yielding creation, then can one assert: These nine are not unique?

No one can deny that water, under the conditions to be found on our planet, is unique. Now, the point which I wish here to make is: That these conditions are as unique and essential, so far as life is concerned, as water itself. We know something of the physical chemistry of solutions, true solutions and colloidal solutions. We know something of the properties of the heterogeneous solutions compounded of true solutions, colloidal solutions, and their intermediates. We have compiled considerable information respecting the special properties of gels, whether produced from compounds of the life elements or from other compounds. We have no little information regarding rates of absorption and adsorption, regarding osmotic pressures, regarding the weights of the chemical elements and compounds involved in these phenomena and the relation between these weights and the characteristics of absorption, adsorption, and osmotic pressures, regarding the rate of mixing of different substances (diffusion), regarding crystal formation, shape of crystals, optical properties of crystals, regarding permeability of membranes, regarding energy transformations in various types of matrices compounded of various types of elements, and regarding coagulation points, freezing and boiling points, rates of evaporation, rates of migration of various kinds of charged particles (ions), and reversals of phase associated with the concentration of different species of ions. Rates of heat absorption, transmission, reflection, and refraction; rates of light absorption, transmission, reflection, and refraction; electrolytic phenomena; and the relations holding between electronic vibrations within the atom and the electro-magnetic waves rushing out of the atom—a multitude of facts with reference to such physico-chemical activities we do have.

On the other hand, we have the knowledge of the biophysicist and the physiologist: the vital significance of carbohydrates, fats, proteins, phosphatides, alcohols, ketones, aldehydes, and innumerable types of organic compounds (including vitamins); the life-import of the stimulators of reactions (enzymes); the vital meaning of the weights, concentrations, balancing effects, stimulating effects, inhibitory effects, regulatory influence, and thermal and optical properties—of the substances which do conjoin to lift the inanimate to the plane of the animate.

Now, let the physicist converse with the biophysicist and the physiologist. Let them refer again and again to their respective tables. Let them check and recheck the precise influence of this energy-condition and that energy-condition upon the potency of any group of elements, and let them begin to draw up surmises in regard to the necessity of this condition and that condition to the ultimate product toward which they are, in theory, progressing. Cutting short an interminable history, wherever it is cut, they will find that all lines, along which they have progressed, are leading in the direction of nine elements suspended by thinnest threads of specific types. These threads are as much a part of the life-web as the life elements. For these threads there are no substitutes. For the nine elements there are no substitutes. The filamentous qualities of the nine interwoven with the energy-threads make the net which alone can entrap that elusive miracle: the world of the quick, the sentient, the emotional, and of the human brain-mind.

Energy-varieties condition and are conditioned by substance-varieties, and all is very delicate in its balance and very great in its intricacy. Thus alone do we get a first-rate miracle to wheel about a second-rate sun.

There is, in truth, a mystery wrapped in nine bundles and there are other mysteries in eleven more bundles—all tied with secretly twined and intertwined threads of Force.

Geology, Astronomy, and the Life Elements

In geology, we are impressed with the conception that almost all, if not quite all—as is probably the case—the chemical elements are essential to that type of magma or surroundings in which protoplasm is able to take being and development. Many of these elements may not be directly concerned in the metabolism of any living thing, yet are clearly necessary to the origin and evolution of life. And of course some of these elements not only are necessary to animate nature as forming a portion of a favorable environment, i. e., one favorable beyond being a mere source of the bioelements, but also are themselves bioelements.

It is impossible to imagine the presence of life in a world made up entirely of gases. Also, the highest forms, at least, are unable to dwell in a liquid medium, and must have, as a foundation for their habitats, a solid and fairly stable material. Nevertheless, this fundamental medium cannot be static. It must be a dynamic, though a *gradually* altering mosaic. And the matrix must consist of three interdependent variables: the three phases, solid, liquid, and gas. And each phase is, of course, the integration of countless small, related variables. A certain degree of flux produces those metamorphoses and cycles upon which the existence and the evolution of the most complex organisms depend—and possibly the existence of the majority of lower plants and animals.

So, geological changes, and other lesser events involving variations in earth-features, and in the composition and transportation of the soil, the waters, and the atmosphere, are indirectly but distinctly life processes.

Among the environmental elements of primary significance are:

OXYGEN	CALCIUM	HYDROGEN	PHOSPHORUS
SILICON	SODIUM	TITANIUM	SULFUR
ALUMINUM	POTASSIUM	CHLORINE	BARIUM
IRON	MAGNESIUM	CARBON	MANGANESE

What if any other element, since the origin of the earth, had been in place of one of these? Or even if there had been different proportions of isotopes of the various elements in this list? The whole history of the earth and of earth-life would have been profoundly modified, and, in fact, it seems more than a probability that there would have been no history of earth-life: for, almost certainly, protoplasm would never have appeared. A change in the types and proportions of the environmental elements would affect a tremendous number of factors, such as the mass of the earth, the pull of gravity, the length of the year, the distance from the sun, the rates of absorption and radiation of heat and light; the specific heats of the various portions of the lithosphere and hydrosphere; climate; the composition of and chemical reactions in the soil, the waters, and the atmosphere; the rate of loss of atmosphere from the earth; stream-flow; tidal phenomena; the rates of erosion; the elevation and sinking of continents; the velocity of molecules and ions; radioactivity; and a host of other physical and chemical attributes of the environment. In view of such a complex of interrelated factors, should even the least of the environmental elements be absent, organic nature must likewise be wanting.

And such is the relative abundance of the bioelements throughout the universe in general, and such are their peculiar properties that, by weight, they constitute over 90% of the atmosphere, hydrosphere, and lithosphere of the earth. The nine basic bioelements form over 60% of the earth's one-half mile crust. In short, not only do the bioelements have precisely those chemical and physical properties which fit them for their roles in protoplasm, but also, by reason of these same sharply defined properties, they are the sole suitable constituents of the major portion of the sole possible environment for life.

Astronomy, physics, and chemistry have united to give us an additional remarkable picture of these same nine elements of the biocomplex, taking another invaluable but far different part in the life-drama.

The sun is the scene. There, their activities go on apace, in what was once thought a mad dance of the children of chaos. Wild is their rhythm, it is true, and fantastically fierce the tempo. But rhythm they have. And the tempo is not unrestrained. For, as the naked atoms, stripped of their electrons, dash to and fro in their swirling passage, their excitement attains white-heat, and from the countless swarms, myriads of scintillations arise to total a mighty flame. Its rays travel onwards to the earth, where men find them a life-giving harmony of color, whose gentle impact is a true vital impetus.

Therefore, it is apparent that an element, to earn the privilege of being a life element of basic importance, must be able to meet a tremendous variety of demands. It must be adapted in almost countless ways to co-function with other elements of peculiar types in the multivaried organic processes. It must perform a great series of duties in the terrestrial environment, of which life is actually a part. Finally, it has to engage, with the other elements, in the task of showering solar radiation, of precisely the suitable intensity and wave-length, upon the earth and its offspring. With these considerations in mind, it is not difficult to understand why no two elements out of the ninety-two can subserve the same life functions, and why life is conceivable only when the organism is constructed of a special group of elements.

Conviction on these points is strengthened when we recall that the elements are, as demonstrated by the whole system of modern chemistry, built according to a plan, and that an orderly rise and fall, in the degree to which a given chemical or physical property is exhibited, is the rule. So evident are these facts that the elements can be classified upon the basis of similarities and dissimilarities, as in the periodic table. No two elements can occupy the same position in any periodic table; there are always significant differences between them. Therefore, it is for this reason, in part, that the structures and processes of organic nature are clustered around a special set of elements; where we have a phenomenon so complicated and so specifically and delicately dependent upon a seemingly limitless array of interrelated factors, as life, then a distinct choice of component elementary materials there must be, or the phenomenon not occur. Further, when we observe that the phenomenon is of the highest order of complexity and is dependent upon the properties and activities of the majority of the elements besides its component bioelements—perhaps all of them—then indeed it must be that life is the central scheme of the periodic table, the chief theme of the harmony of the elements. And one should not hesitate to suspect that it will prove true that the only completely satisfactory and natural classification of the elements will be one based upon their life-producing phenomena. Certainly this is a logical deduction from the observation that, ever as knowledge increases, we perceive deeper and deeper relationships existing between the life processes and the properties of the elements.

H. G. Wells, in his "Science of Life," terms the kind of life with which we are familiar on the earth, alpha life. He suggests the possibility of there being elsewhere, beta life, made up of a different collection of elements, say with silicon undertaking the role of carbon; and even the possibility of gamma life, delta life, etc.

Barnes, in his "Scientific Theory and Religion" expresses the opinion that "had not an element been initially available, living tissue would have made another kind of building material serve its end"; and that "one is left with the feeling that even if carbon, hydrogen, and oxygen had not been available, life might have found elements which would have been adequate for its needs"; "Il faut vivre; and if iron is not available, copper will suit."

Ammonia, at ordinary temperatures and pressures is a gas—the gas that comes out of an unstoppered bottle of household ammonia (a solution of ammonia in water). When cooled and compressed, this gas may be made first liquid and then solid.

There are remarkable resemblances between the physical and chemical properties of water and ammonia. In its solvent power for salts, in its power for dissociating electrolytes, and in its ability to form complex crystalline compounds, liquid ammonia closely approaches water. Its critical temperature and critical pressure, its boiling point, and its atmospheric pressure are as strikingly high as with water. The common acids, bases, and salts, which we may call aquo compounds, since they may all be thought of as derivatives of water, have their analogues among the ammono compounds. In brief, a very complete ammono chemistry has been built up, and corresponds in numerous ways to our much more familiar aquo system of reactions.

Since quantities of ammonia occur in the atmospheres of Jupiter and Saturn, certain chemists have been led to speculate concerning an ammonia world. Some of these men have gone rather deeply into the chemistry of such a creation, and have evolved an engaging picture of a new system of organic nature. Upon Jupiter, for instance, they depict liquid ammonia oceans, rivers, and streams extending beneath the ammonia atmosphere. The rocks and soils are of compounds known only to the organic chemist, but apparently they might serve just as well in the way of a substratum and fundamental store of materials for life as earthly rock and soil. Liquid ammonia and ammono compounds would in every way serve to replace water and aquo compounds, so that out of a chemistry of ammonia instead of a chemistry of water, an ammonia vegetation blossoms forth, to be fed upon by ammonia creatures corresponding to the earth-dwelling insects, worms, fish, and reptiles whose constitution is largely water. There might even be an ammonia man quenching his thirst with liquid ammonia, and appeasing his hunger with nutrients whose chemical formulas are different from but analogous to those of the compounds in the diet of earth-man.

But the imagination which has a love for the actual, must find its delight in other regions: there is only one possible fundamental type of living material in all the mighty expanse of space. This sole possible basis of life is the protoplasm born of our planet. Beta, gamma, delta, and ammono-life systems are not actually possible, and are fabricated in dream-like fashion, out of only a partial awareness of the true circumstances of reality. As we have seen, life is woven out of countless gossamer filaments, whose ramifications extend throughout the entire cosmic web and whose unimaginably fine and sensitive rootlets absorb their being and their sustenance out of an entirely unique selection of elements, each an individual and incomparable pattern of qualities.

Should we desire to reach a yet higher degree of certainty regarding our conception of the living thing as a metabolic organization whose sole possible basis is the biocomplex mentioned, and as the chief phase of the universal plan, we are still able to draw upon the inexhaustible reservoir of facts supplied by the scientific researches of the past several years. Some of the more meaningful and more readily grasped considerations along lines not yet discussed are as follows.

If a beta form of life is possible, why has it not originated on the earth, where we find all of the ninety-two elements, and where there are other elements besides the bioelements which are widespread and abundant enough to permit of their being used by that mysterious something which "faut vivre"? There is no evidence indicating that such a life-type has been upon the earth in the full hundreds of millions of years in which conditions have been patently favorable to such a creation.

Chemistry has disclosed the existence of isomers, which are compounds that have the same number and kind of component atoms, and therefore must be given the same formula. Some of these are so closely similar that they differ only as the right hand from the left, one being the mirror-image of the other. Upon the theory that organisms arose by "chance" we should expect that in them we should find both kinds of mirror-image isomers appearing equally often. But it has been determined that, in the whole range of animate nature, only one kind of molecular symmetry can be utilized in the vital mechanism. And here we are not talking of simple and separate atoms, but complex molecules of atoms. We have lifted the argument to a higher plane, where a novel and more intricate play of phenomena is concerned. And here we observe a new grade of specificity to which an element must attain in order to be a bioelement—and a new indication of the unimaginable delicacy and intricacy of the protoplasmic organization. That is, a life element must not only be able to help in the construction of a wondrous variety of molecules, but even must be capable of assisting in producing a certain peculiar and definite symmetry of molecular architecture. Even the mirror-image of just the appropriate molecule will not be the needed cog in the life machine. Moreover, if life is again, a mysterious power which "faut vivre," why will this power starve to death when the mirror-image of the compound it desires is heaped in abundance around? Would this odd power, then, be expected to be able to swallow the far cruder differences between elements, and so assume a material shape when a bioelement is unavailable?

Isotopes are varieties of the same element which have identical chemical properties (so far as the chemist is aware) and identical physical properties, except that one isotope is always ever so slightly heavier or lighter than another isotope of the same element. Most elements are mixtures of isotopes. For example, hydrogen gas, as it occurs on the earth, whether free or combined, is always a mixture of three kinds of hydrogen that differ from one another only with respect to an almost infinitesimal affair of weight.

If life is *that which necessarily lives*, and if it is capable of manifesting itself through the medium of more than one sort of basic biocomplex, should we prophecy that experiment would, in the case of a bioelement, demonstrate one of its isotopes to be toxic—whereas of course, the element of which this isotope is part, is essential to life? Heavy water is water whose hydrogen is chiefly the medium-heavy isotope; recent experiments show that concentrated heavy water is poisonous. Water, of all compounds,—the most intimately related to life! In very truth, fragile are the strands of the vital web; and sharply defined the conditions of its existence, as well as exceedingly narrow their limits. Bound up with the most minute distinctions of which physical chemists are aware, life is ever more clearly delineated as the main aspect of the plan behind the structure of the elements.

Another striking fact is that none of the twenty bioelements is a mixture consisting of more than three isotopes. Yet once more, the life elements must be of most highly specific natures. Unsuspected profundities of relationship, as well, unite them into a group apart from the rest of the elements, which, taken all ninety-two together, are like a setting for the the jewel of life.

The Periodic System and the Bioelements

It has been suggested that since the secret of life is hidden deep within the innermost nature of the cosmos, one should not hesitate to assume a connection between life phenomena and the classification of the elements. And it has also been mentioned that there is a definite and by-chemists-neglected connection between the bio-elements and the difficulties met with in classifying the elements—for no periodic system is completely satisfactory or entirely logical.

Hydrogen has no logical position in any periodic table yet devised. Though hydrogen is sometimes grouped with the alkali metals, it has numerous affinities with the halogens. To cite a single illustration, hydrogen and chlorine are mutually replaceable in many organic compounds without alteration in the essential characteristics of the original substances. Hydrogen is neither metal nor non-metal—using the term metal in its widest sense. In hydrogen we have an element which is uniquely important to life and uniquely important to the chemical taxonomist.

Then, as every chemist will admit, carbon and silicon have no close chemical analogues, and must occupy peculiarly illogical positions in the table.

The atomic weights of argon and potassium are not in the regular order. In the older classification, according to atomic weight, their atomic weights had to be disregarded in order to bring these elements into a natural alignment. At first sight, it might seem that the arrangement according to atomic number removes this difficulty; yet, even so, there remains the anomaly of two elements with their atomic numbers in correct order but with transposed atomic weights. Apparently also, the existence of isotopes of argon (A36 and A40) and of potassium (K39 and K41) "explains" the situation: as chemists happily dismiss the irregularity—if there *happened* to be a larger proportion of A36 in argon, and a smaller proportion of K39 in potassium, the atomic weights *would* have the expected sequence. Nevertheless, no matter how we explain it away, the anomaly is still the actuality. And, of course, potassium is the bioelement concerned in this anomaly.

Also, not only is potassium the only radioactive element of which protoplasm makes use, but it is, besides, the only radioactive light element—which provides us with another anomaly in the periodic system. Even should it be ultimately demonstrated that all elements—as has been speculatively suggested—are at least feebly radioactive, nevertheless, potassium would still have a singular position among the light elements as far and above the rest in the rapidity of its disintegration.

The interpolated elements following calcium: Bohr's periodic table perhaps best emphasizes the properties accompanying alterations in the distribution of electrons in orbits of different principal and azimuthal quantum numbers, occurring as the elements are successively constructed. That is, when we find the longer periods departing from the simple patterns of the two shorter periods, it marks the completion of certain phases in the building up by added electrons. Upon the basis of spectroscopic determinations, Bohr was able to prove that with calcium one of these stages of atomic upbuilding is completed, and that the elements

SCANDIUM	MANGANESE
TITANIUM	IRON
VANADIUM	COBALT
CHROMIUM	NICKEL

should be segregated, and can be termed *interpolated elements*, as having no direct relation to any elements preceding them.

At any rate, at calcium there occurs a serious break in the periodic repetition of features, and this irregularity can only be due to a fundamental change in the structure of the atoms as they increase in atomic number.

NOTE: From the viewpoint of the biologist, calcium is one of the most important of the bioelements, all but a very few (lower) organisms requiring it. Briefly, the most important known and probable life roles of this element are:

PLANTS

a. In higher plants at least, it is thought that calcium pectate, as a constituent of the middle lamella of young (non-lignified) tissue, regulates the permeability of the cell wall.

b. Certain essential proteins of calcium-requiring plants apparently have this element as an irreplaceable component.

c. Calcium functions in the digestion and translocation of carbohydrates (and possibly proteins). The storage of carbohydrates and protein also seems affected by lack of calcium, especially in the case of seed development. (Possibly, flowering plants which are saprophytes need less calcium than autophytes because the former do not require it in the digestion and translocation of carbohydrates as produced photosynthetically.)

d. Calcium aids in antagonizing the toxic effects of salts of sodium, potassium, and magnesium.

e. Certain plant physiologists hold that calcium is necessary for the neutralization of acids formed during metabolic activity.

ANIMALS

a. Calcium is utilized as a component of protective and supporting structures, in the form of calcium carbonate, found in the internal and external skeletons of Foraminifera; in the calcareous spicules of sponges; in the spicules and skeletons of corals; in the secreted tubes of marine worms; in the shells of Molluscoida; in the plates of the calcareous exoskeleton of Echinoderms; in the calcified chitin of the sclerites of certain Crustacea; and in the shells of Mollusca.

b. The shells of eggs contain calcium carbonate.

c. Bones and teeth consist largely of calcium phosphate and calcium carbonate, in the ratio of about 3: 1, and act as reservoirs of this element.

d. The calciferous glands of certain Annulates secrete calcium carbonate in order to neutralize acid foods.

e. Calcium ions are essential in the clotting of blood.

f. Milk not only contains calcium phosphate, but also calcium in combination with caseinogen. In the clotting of milk by rennin, this enzyme converts caseinogen into casein, which latter substance produces the clot upon union with calcium. Thus gastric digestion of casein is made possible.

g. In the regulation of heart-beat, calcium opposes the effects of sodium and potassium. Definite proportions of calcium, sodium, and potassium must be present.

h. In the case of skeletal-muscle contraction, the stimulating action of calcium is an antidote to potassium inhibition. Calcium ions are also necessary to counteract the effect of sodium ions.

i. Nervous tissue seems to use relatively less calcium than other tissues, but the transmission of the nerve-impulse cannot occur without calcium, which also must be present to antagonize the action of magnesium.

j. The permeability of the cell membrane is altered by changing the concentration of the calcium ion. Apparently, the diffusion rates of other substances are determined by the ratio of calcium to sodium and potassium ions.

The breakdown of the law of octaves: Following manganese, an inert element similar to helium and argon would maintain the regular recurrence of properties established in the first part of the system. Instead, three closely related elements, iron, cobalt, and nickel, occur. For them, a special "transitional group" (Group VIII) must be created. Both manganese and iron are life elements, and there is some evidence that nickel is also.

Manganese is a necessary constituent of the respiratory substances of certain lower animals, and there is some evidence that it is needed by mammals, if only in traces. Iron belongs—as we recall—to the basic complex of nine bioelements, and fits into the complex as an agent in biological oxidations.

Furthermore, there is most certainly something deeper than mere superficial association in the fact that the particular region of the periodic table under discussion is so rich in life elements with respiratory functions—indeed, all of the known respiratory bioelements are here found: iron, vanadium, manganese, and copper; and the first three of these are among the peculiar eight "interpolated elements" which follow calcium.

In view of all the fine details of relationship existing between life and the bioelements, and among the bioelements themselves, it would appear beyond doubt that both the irregularity of the system as evidenced by the interpolated elements, and the breakdown of the law of octaves are definitely bound up with the nature of the life elements.

The position of copper: Copper forms colored salts; it is often divalent; spectrally, it is somewhat similar to the interpolated elements which it follows; and beyond the facts that it is sometimes monovalent and to a certain degree spectroscopically resembles the alkali metals, there is no good reason to place copper in Column I. But since zinc clearly belongs in Column II, there is nowhere else to put copper but in Column I, if we should have a symmetrical arrangement.

The irregularity caused by the inversion of the atomic weights of iodine and tellurium, is a case similar to that of argon and potassium. Iodine functions as a component of thyroxin, and is believed essential to many marine forms.

The first element in a column is usually not a typical element. No matter what type of periodic table is resorted to, this difficulty cannot be overcome. The uppermost elements in the eight columns are:

HYDROGEN	NITROGEN
BERYLLIUM *	OXYGEN
BORON	FLUORINE *
CARBON	IRON

Whether or not we essay to explain the connection between the life elements and this difficulty by the statement that the relation is natural in view of the fact that the bioelements are mostly light elements—still the difficulty is real. And in the light of the knowledge that in remarkably numerous ways the life elements are peculiar, as shown especially strikingly perhaps by the failure of all attempts to substitute (in any life process) any element for a bioelement, this additional hindrance to a symmetrical and meaningful arrangement of the elements would appear to take on added significance.

As regards boron, at the present stage of biochemical research, this element is known to be essential to only a limited number of species of higher plants; but it too is unique so far as its life role is concerned: no other element can take its place. Further, boron does not well fit into the position given it in the periodic table, for, it is the only non-metal in its group (Group III)—and the only life element.

Other obstacles in the way of making a chemically

* Not a life element.

acceptable table of the elements are to be found in the so-called "twin elements," in the necessary but illogical separation of carbon and boron, the relationships existing between magnesium and manganese, the necessary but illogical separation of copper and mercury, the multivalent elements, the position of vanadium, and the relative abundance of the elements throughout the earth and the cosmos in general. With all of these difficulties, the properties of the life elements are closely bound up.

There are several difficulties, of course, with which the life elements do not have any yet evident connection: the inversion of the atomic weights of cobalt and nickel, the allocation of the rare earths, and the allocation of the radioactive elements (excepting potassium). But nickel may yet prove to be a life element. Moreover, as respects the rare earths, until more is known concerning their distribution, concerning "oligodynamic elements,"* and concerning the roles of these elements in the evolution of the earth (itself a life factor), it would be fair to expect a suspension of judgment involving things protoplasmic.

The radioelements are unable to participate (in more than infinitesimal quantities) unless injuriously, in any

* Elements whose effects are marked, though the element may be present in almost undetectable quantities.

physiology, because of their great effusions of energy, as well as their high atomic weights. This does not mean, however, that life could exist without them. The radioactive elements aid in the ionization of air, which is very probably a phenomenon essential at least to air-breathing forms. Furthermore, since more intense, though less prolonged radiation than occurs in Nature, can be made to produce mutations in the laboratory, it has been suggested that the emanations from radioactive elements have aided in causing evolution by inducing mutation. Finally, extremely minute traces of heavy radioactive elements must occur in every living thing—if only "adventitiously."

"Why Should We Expect Any Irregularity To Exist Among Them?"

Clerk Maxwell, the brilliant physicist of two generations ago, before anything was known about the structure of atoms, predicted that they would be found quite uniform, and asked, "If we suppose the atoms to be made at all, or if we suppose them to consist of something previously made, why should we expect any irregularity to exist among them?" In view of what we have ascertained concerning the peculiarities and the specific vital fitnesses of the bioelements, we can now answer: "That life may be." The profoundest investigations of the chemist and the physicist illumine the fact that, in this instance as innumerable times before, apparent irregularity is but a portion of a previously unperceived, transcendent order—of an unsuspected grandeur of regularity.

Having contemplated something of the universal interplay of matter and energy as science has made it visible to us, we are able to discern a magnificent pattern at whose center lies the world of organic beings. The material portion of this pattern is made of ninety-two elements, nine of which have that uniqueness of character which alone permits of their being blended to form the basic design of life.

Man Is More Than These

But man, like most living things, is of a stuff that must be constructed of more than these fundamental nine. Like many living things, he must also have calcium, chlorine, sodium, iodine, and copper. These five too are unique in their properties, and irreplaceable in the human physiology. They too have chemically and physically a seeming infinity of the most complicated and nicest adjustments; and the supreme integration of them and the basic nine is man.

His brain gives man the supremacy in the organic world—and in the universe as a whole. The ultimate in protoplasmic evolution, man's being is indissolubly linked to every fundamental factor in the world process. The logic of the case is infinitely more involved than, but definitely as distinctly clear as the logic which permitted chemists to arrange the elements in a geometric pattern.

Our thoughts now carry us down to the bedrock of the cosmos, amidst the towering shadows whose blackness was once believed the gloom of madness, but which now we feel to be the friendly adumbrations of coming knowledge. For the first time, light, dim light, is visible. But it is light, however dim. In truth its glow is not so feeble that we cannot make out something of the bedrock, and learn a little concerning its texture. Its texture is exceeding fine and delicate-appearing, and we are immediately disappointed, for we expected to find a mighty support, of surpassing strength. What else would hold the giant pillars of the universal structure? We look again. Again we are disappointed. The pillars are themselves of the same fragile texture.

But an idea comes to us. We examine pillar and bedrock. Not rock at all, they are a single, filmy fabric; yet, withal, a unit and a fabric. The strands of the one are the strands of the other. We are reminded of the organic filaments which we have left behind on the earth: filaments of a tensile strength beyond that of steel tempered in man-made electric furnaces. Firmness there is, then, in this underlying fabric of creation, and firmness greater than that of rock. We are reminded of earthly organic filaments because they are but the threads of the original cosmic web extended into a higher synthesis, whose pattern centers about man. As we return to earth, we might discover ourselves thinking of the words of Aristotle: "There can be nothing in the end of a process that was not present in kind in the beginning."

CHAPTER VII

The Secret of the Human Brain

EACH NEW development in the physiology of the nervous system brings out ever more forcefully the vastness of the system of the human brain. Now it can with confidence be described as surpassing all the phenomena of creation in the wondrous harmony of its countless interlacing themes. A single one of its cells is a more intricate organization than the most populous city. The highest product of evolution, the human brain so magnificently transcends by its boundless powers its nearest likeness, the simian brain, as to bring a new order of things into the cosmos. Though the dawn of human rationality did not mean a sudden break with the past gradual evolution of psychic machinery among the primates, and though there has been a somewhat similar evolution of mental processes in many other mammals, nevertheless, the human mind does have distinctive attributes. The ability of man to frame abstract concepts and to reason concerning them has no parallel.

But if the brain is so stupendously intricate a structure, how can we speak of the *advance* of psychology?

Yet has psychology really advanced very far on toward its chosen goal? An opinion on this subject runs as follows:

"When, then, we talk of psychology as a natural science, we must not assume that that means a sort of psychology that stands at last on solid ground. It means just the reverse; it means a psychology particularly fragile, and into which the waters of metaphysical criticism leak at every joint, a psychology all of whose elementary assumptions and data must be reconsidered in wider connections and translated into other terms. It is, in short, a phase of diffidence, and not of arrogance; it is indeed strange to hear people talk triumphantly of the New Psychology, and write histories of psychology, when into the real elements and forces which the word covers not the first glimpse of insight exists. A string of raw facts; a little gossip and wrangle about opinions; a little classification and generalization on the mere descriptive level; a strong prejudice that we *have* states of mind, and that our brain conditions them; but not a single law in the sense in which physics shows us laws, not a single proposition from which any consequence can causally be deduced. We don't even know the terms between which the elementary laws would obtain if we had them. This is no science, it is only the hope of a science.

"But at present psychology is in the condition of physics before Galileo and the laws of motion, of chemistry before Lavoisier and the notion that mass is preserved in all reactions. The Galileo and the Lavoisier of psychology will be famous men indeed when they come, as come some day they surely will, or past successes are no index to the future. . . .

"Meanwhile the best way in which we can facilitate their advent is to understand how great is the darkness in which we grope, and never to forget that the natural science assumptions with which we started are provisional and revisable things." *

It would probably be an understatement to say that a large number of psychologists would resent this criticism as unjustifiable. I wonder if their ire would be diminished, when they remembered that this is the judgment of one of their own group—no less a figure than William James. And the truth of this judgment is still unaltered, because neither the Galileo nor the Lavoisier of this science has yet arrived.

But if he has not yet appeared, psychology need not be ashamed. When Lady Astor looks to her horse, preparatory to an afternoon's outing, her thoughts can course through any one of more than 102,783,000 paths extending through her cerebrum. There are more than niney-two hundred million nerve cells in the covering (cortex) of the cerebrum alone. And the possible patterns of interconnections between these cells, used as nerve-pathways during a few moments' cogitation may approach infinity.

"Every neuron of the cerebral cortex is enmeshed in a tangle of very fine nerve fibers of great complexity,

* William James, *Psychology*. By permission of Henry Holt and Company, publishers.

some of which come from very remote parts. It is probably safe to say that the majority of cortical neurons are directly or indirectly connected with every cortical field. This is the anatomical basis of cortical associational processes. The interconnection of these associational fibers form an anatomical mechanism which permits, during a train of cortical associations, numbers of different functional combinations of cortical neurons that far surpass any figures ever suggested by the astronomers in measuring the distances of stars." *

Of *this,* however, not only psychology but every branch of science ought to be ashamed: That psychology and every branch of science do not know or else continually forget the exceeding mightiness of the complexity of the brain.

"The inconceivable intricacy of the structural connections within the brain is generally underestimated even by neurologists. And to speak of memories or any other unitary cortical functions as localized in some particular cells or in some small cortical area is to talk neurological nonsense." *

Most of our psychologists have not passed beyond the intriguing simplicity of the phrenology phase of brain-lore. Otherwise they would vociferously resent the scornful opinion of other branches of science that that little three-pound structure of white and grey matter in which they find life-long bafflement was swept

* Robinson and Robinson, *Readings in General Psychology.* By permission of the Chicago University Press, publishers.

together by the cosmic winds wantoning through wandering atomic dust.

James is not quoted by way of showing the inadequacy of science. Rather the advent of really scientific psychology is to be expected and welcomed—and all must agree with James that some inspired day psychology and physics will be on a par with one another, especially since there *has* been a steady advance in the application of physico-chemical principles to the study of the nervous system. The approach of a true physico-chemical psychology means that, in a far greater sense than ever before, the universe is demonstrably a place of order. Man can be surer of the absence of chaos, the presence of a hope-instilling pattern, and the opportunity of fighting through many a fearful, dragging combat to a high destiny.

The Laughter of the Gods

The post-midnight oil in my lamp has often rippled and quivered so that at odd moments the flame violently flickered, even threatening to vanish entirely and leave my thoughts in darkness. The windows were closed and there was no indoor breeze or draft. I do not believe in ghostly breaths. The earth must have been quaking, though I had no seismograph to vibrate out a check on my theory. There was no other explanation.

A little introspection sufficed to demonstrate that my thoughts were running along lines which were monstrous enough to have been received by telepathy at a great distance. Those sensitive to and lying in wait for such disrespectful ideas as mine could have read them with clairvoyant ease. The quakes were indubitably due to the laughter of the Gods afar off—the Gods in Scientific Authority.

My thoughts had been naive, ineffably naive, because irreverent of the Gods' impressiveness of authority. I had been thinking, as often, that the heart of the cosmos and the mind of man were one.

The Naive Psychology of a Layman

The large explanations come from the investigators with a large grasp. The wide-eye sees the wide principle. But it will take an omni-visioning physico-chemical psychologist to reflect for us an understanding of the body-mind problem. Huxley thought that

"It may be that, by and by, philosophers will discover some higher law of which the facts of life are particular cases; very possibly they will find out some bond beween physico-chemical phenomena on the one hand and vital phenomena on the other."

In a world of order, there must always be a general principle uniting particular instances. And since vital phenomena, including mind, develop in all their intricacy out of avital materials and forces, there must be, in a world of order, some bond yoking the vital to the avital. There must be a higher law (causal relationship) yoking mind to fourteen chemical elements and their energy-induced activities.

Thinkers often speak of the influences which, throughout the course of evolution, have co-operated to produce brain and human mind. The word "influence" is too narrowly anthropomorphic in this connection. It brings to mind an image of a haphazard clash of forces—forces emanating from the fingers of our shadow-enshrouded, mystic, dice-throwing Fortuity. Back of *influence* lies the rough, non-natural idea of an anthropomorphic "shove" or "push"—blind urge—toward a hoped-for, but uncertain integration.

The brain-mind has flowed naturally out of the gravid substances of creation. It is an exfluence, i. e., a secretion, of its environment—and not a static environment or one without an unimaginably long history behind it. Whence comes the environment? At a given moment, it is flowing out of countless infinitesimally tiny springs which unite to make broad streams and at last a great ocean alive with currents, countercurrents, crosscurrents, and suboceanic creeps. Whence the tiny springs? They are exfluences of tinier exudations from the innermost core of the cosmos. And the core itself, what of that? An exfluence of no man-conceivable Thing—if you like meaningless terms, or meaningful, if you choose, then, the exfluence of a First Cause.

Itself infinite in its potentialities, the brain-mind is the exfluence of an infinity of exfluences.

Do these excessively broad terms have any significance to common sense? From the very nature of the case, they cannot have much. But they do have some import: When we, as psychologists, professional or amateur, try to deal with the human mind, we are baffled—because we have met again with the Infinite. It will indeed call for a large principle and a large-minded investigator to cope with the problem successfully.

We may go even further. In a world of order, where all things are related, there cannot be more in the end of process than was present in the beginning. Creative evolution is a descriptive term applied to the exfluence of brain-mind from the exfluences of the first Beginning. In one sense, the brain-mind of man represents something new and emergent. But it is in fact *emergent,* exfluent from the Beginning which was pregnant with it.

If others can read into my words what I see in them, it is to be found that I feel the brain-mind is intricate and large enough a creation to absorb and unify all of the various interpretations of its problem, and show that each of these interpretations has some truth in it. The principle of which the brain is a particular instance is grand enough to include the interaction theory, the parallelism theory, and the materialistic theory of the brain-mind. Superficially, this appears absurd.

As to the interaction theory, as the interactionists state their case, there seems a plausible likelihood that mind and matter can react and do react, one upon the other—but in no crude, physics-and-chemistry-transcending fashion. One would rather suggest that, in view of the astounding interplay of matter and energy exemplified in the brain, physics and chemistry simply are as yet too ignorant to say that the interaction theory violates the principles of their science. What does any one know of the workings of the brain? Very little, almost nothing. What attention have the broad theorists in physics and chemistry given to that highest exemplification* of the co-ordinative activities of those particles and forces with which the theorists would adequately deal? None. And, in a sense, it is outside their field—but merely because of pragmatic considerations. May these be temporary.

* Of course: the brain.

Can any common sense individual doubt the materialist when he says that mind is a form of matter? Does not mind flow out of the properties of matter? Examine more deeply the properties of matter, and, common sense says, you will find the promise of mind.

And is not mind, in a sense—a very logical sense—an epiphenomenon caused by matter? What else could it be? Matter, the explanation must run, has strange, astoundingly strange, properties, which, however outrageously outlandish to the physical chemist, must nevertheless exist. The deepest logic could not say otherwise. Matter makes the freak, brain.

The dualistic parallelist is in error only when he denies that matter and mind can interact; but he is correct when he emphasizes the parallelistic correspondence between brain states and mental states, and when he says that the mind cannot act outside the realm of physics and chemistry. A second error which he introduces is one of an adjective: he is prone to assert "mind cannot act outside the *known* realm of physics and chemistry." Leave out the adjective and we have the hope left to us of a larger physical chemistry, and a closer approach to an understanding of the brain-mind.

Materialistic parallelism, idealistic parallelism, and "the double aspect view" each choose to overemphasize the significance of certain really existent phenomena. They are only in error when they deny that physics and chemistry will grow large enough to grasp what it means for mentality to be associated with material forces.

Almost everyone forgets that when the active brain is presented to him, he is looking at an organization of material forces *whose very nature* it is to sense, to coordinate, to adjust, to feel, to think, and to act, when they are so organized.* He forgets the intricacy and the delicacy of the phenomena which he is regarding. And, I suppose, so wondrous a thing is the brain-mind, that he is to be forgiven for becoming lost in amazement at some special aspect of that which is the infant born of and nurtured by all significant exfluences of the cosmos.

The laughter of the Gods grows into a more terrifying rumble. What asininity are these words? Why, man

* Time and space and The First Cause are not the only ineffable Infinities. The brain-mind, the sensuous-sentient-sensible grade of organization of matter-energy, is another. And so therefore—because this is a linked cosmos—the ideal atom model, fitting the grooves of the atom-slinging machine as well as the grooves in the Aristotelian, the Kantian, the Newtonian, and the Einsteinian brain-mind, must also be an Infinity. (The atom is not sentient. But it has the potentiality, in common with its fellows, of corporealizing a new, but anciently promised, State or Grade of Organization. The ancient promise was merely the nature or architecture of the atom itself—as it cavorted in the fiery gas of our nebula, the ancestor of our solar system).

and all his little instruments, like the brain and hands, are evanescent incidents—of the nature of infinitesimals beside the Grand, Unknowable Infinite. Why, man could not even reach up and chin himself on the gutter of insignificance. An infinitesimal is too small to do that.

And yet—what of the web of life?

CHAPTER VIII

The Web of Life

IF MAN were dependent upon a very minor portion of the environment out of which he naturally arises, his significance to the universal cinema would be no greater than that of the very minor fraction giving him his being.

If man were knit out of all the larger cords of the cosmos—if his design were an ornament necessarily woven out of the innumerable major threads of creation, with only a very few unimportant filaments left apparently hanging loose, then indeed we might understand that this is after all a man-intent universe.

The Delicacy of Life

Biologists often tell us how remarkably varied the life-supporting environments are. Is it not one of the marvels of Nature, they ask, under what a diversity of physical and chemical conditions living things are found? And amidst what baneful influences, such as scarcity of nutrients and moisture, and extremes of heat and cold, plants and animals can endure? Certain microbes can even feed upon arsenic, selenium, and tellurium—elements deadly poisonous to man.

Yet, when biologists speak thus, they are really anthropomorphizing—and in truth emphasizing the delicacy which is man. That is, from the viewpoint of man, who is a creature unable long to survive temperatures below the freezing point of water or above sixty degrees Centigrade, the ability of bacteria to maintain life even at Absolute Zero, or to dwell in the almost boiling waters of hot springs, is altogether astonishing.

In a larger sense, however, life is not rugged. Its delicacy is—one can be sure—beyond the imagination of the average scientist of today.

Temperature. The intensity of heat in the universe ranges from 273 degrees below zero Centigrade (i. e., where there is no heat) up beyond some fifty millions of degrees. Life can carry on its activities—not just survive—in only one specific and very minute fraction of this great range: a fraction so tiny that it pales into insignificance beside this great scale. Though bacteria can survive temperatures as low as absolute zero, they cannot carry on their activities at such low intensities of heat and so they slowly die off. Though some microbes dwell in hot springs, their lives are ultimately dependent upon the activities of other forms which can live only at much lower temperatures. The range of heat intensity essential to life is between about five degrees (above zero Centigrade) and about forty degrees. This of course refers to the temperature conditions under which the life forms can readily carry on their life processes and over long periods survive—and to the temperatures in the immediate vicinity of the organisms.

But the problem is far from being simple. Temperatures which, when viewed narrowly, appear the agents of death, are, when broadly viewed, the agents of life. Periods of cold are essential to the development of many types of living things. And portions of the earth have to be, for short periods at least, heated to fairly high temperatures: this is a necessary factor in the absorption of heat from the sun, in the production of the winds, the climate—and life-affecting movements of the warm or icy blue-green masses slowly sliding as currents through the salty oceans of our planet.

And variations in temperature over the surface of the earth are part of the story—part of the required environment—part of the web of life. The life-delicacy is dependent upon the moisture-delicacy as it plays in variegated though unseen patterns through our shifting—heat-shifting—atmosphere. The fall of rain, the dew on leaves, the ooze in soil, the solution of the rock-salt; the stream-water, rich in salts, themselves rich in the life-elements, flowing down to the sea, whose very salt-molecules we carry in our veins to this day—these are inconceivably finely balanced phenomena, and upon this fine balance of temperature factors are superimposed the delicate equilibria of what men call rugged, easy-born life.

And the present is not all. The delicate-history is a tale of two billion years. The travail of Nature in weaving together so multitudinous an array of fragile filaments has its equal only in the travail of Nature in keeping them unbroken, agelessly, as one ice-age melts only to freeze into a new glacial epoch.

Pressure. Man and especially lower forms are adaptable to a fair range of pressures. But adaptability has its limits—if not, why is the universe not one grand, writhing mass of protoplasmic jelly? Why have millions of species become extinct? The graph of the pressures over the face of the earth and in the waters resting on the planet's surface—through these centuries of centuries—is a graph of the life possibilities of this earth-planet, a graph of an essential portion of the life scene, and of a meaningful part of the life-fragility.

Radiation. Exfluences of unknown cataclysms in the fancy-defying regions of outermost space: the cosmic rays, day and night, millenium in and millenium out, have showered upon earth, upon its first slimy living, upon its ladder-climbing evolutionary sequences, and upon its up-standing upstart, man. These rays, if only to a minor degree, ionize air, burst atoms—even within the hearts of molecules within our hearts—and in their own small way (as the shortest of waves) generally create havoc when they make a direct hit. Can they have been without their effects through the eons behind us? At least they were not harmful, for man is here and not all men are insane. Some speculative biologists feel that these rays have meaning for the evolutionist, since, in a linked cosmos, every activity has its effect upon every other activity. Perhaps, without them, man would not be here. Yet so little is known of them, that judgment must await more evidence.

More is known concerning the importance of gamma rays, the exfluences of radioactivity which are slightly greater in wave-length than cosmic rays. Their origin is one with the evolution of the elements, being produced with the disintegrative transformations of the heavier elements into the lighter. Their secret is therefore bound up with the origin of the life elements. But there is an even more direct connection between gamma waves and life: they have to do with the maintenance of the internal heat of the earth, the rise and fall of continents, the ionization of the air, and perhaps the production of mutations. All of these phenomena have a direct connection with the origin, endurance, and development of life. And the intensity of these rays as they shoot forth from the radioactive elements in the earth, in the sea, and in the air, has had to be precisely what it has been through two billion years, or earth-history would have been entirely different—and life absent. Too great an intensity, and life would have been destroyed. The careless roëntgenologist loses his bones, fragment by fragment—and gamma rays are "harder" than the X-rays of the roëntgenologist. Intense X-rays even over short periods of application yield lethal mutations in the fruit fly. Too slight an intensity, and the earth would have been far colder, the air far less ionized, and perhaps we would not have had the mutations leading to man or his essential, life-supporting organic friends in the environment: the flowering plants and many an animal now bred by the millions for man's food.

Gamma rays also play their essential roles in the maintenance of the precisely appropriate temperatures and states of matter in the sun, the celestial mother of earth and the grandmother of men. Life's and man's extreme delicacy is at the mercy of the undulations of solar gamma waves.*

The invisible ultra-violet waves, just a little shorter than the visible violet, as they travel to us from the sun lose precisely the correct amount of their intensity in the ozone layer of the upper atmosphere. This ozone layer they themselves produce; they filter out their own deadliness, and then pass to the earth to give its plants and animals the priceless vitamin D. Strengthen the rays; the seeing become sightless, their eyes burned out. Weaken the rays, and the vertebrate skeleton becomes putty and rots into the dust whence it sprang.

The visible octave of rays—red, orange, yellow, green, blue, indigo, and violet—are they unimportant? What alterations would a change in their proportions and intensities have caused in life-history and human evolution? Enough to cause disaster. Color has played as definite a part in evolution as those elements—many of them life elements—whose peculiar vibrations produce color. Is the universe not a close-knit, fragile-stranded unity?

The visible rays also play their roles as heat-vibrations and join with the infra-red in the consonance known to

* These waves do not themselves penetrate to the earth.

us as the system of heat phenomena. Why look to the mystic for miracles when we live amidst and because of them, in a series of boundless, conception-blasting series?

An Objection. Jeans asserts, in his *Universe Around Us:*

"When we arrive on Jupiter, we shall find that we cannot see through its clouds. If, however, we had lived on Jupiter for thousands of generations, our eyes might have adjusted themselves to some special kinds of waves which pass through the clouds of Jupiter. We might have been saying how fortunate we were to live on Jupiter, with its beautifully transparent atmosphere, and pitying the inhabitants of other planets, such as the earth, who were shut in by opaque clouds." *

As this involves one of the most serious objections to any conception of man as of deep significance to the cosmos, it calls for the most careful consideration.

The objection may be stated in broader terms: The adaptability of living things is such that, given slow environmental change, protoplasm would adjust itself to conditions far more varied than those of the earth. The objection may be answered in several entirely different ways.

The earth, so far as we are aware, provides the most favorable conditions for life to be met with anywhere

* Sir James Jeans, *Universe Around Us.* By permission of The Macmillan Company, publishers.

in the wide expanses of the universe. Its geological changes, though magnificently great, have never been catastrophic, but instead characterized by extreme slowness. Therefore life has had more than an even chance, and has responded by covering the earth with its millions of plant and animal species.

Indeed, so great is the power of adaptation common to protoplasms, says the biological philosopher, that we now have "an infinite variety" of living forms which have spread out from their centers of origin until they inhabit "every corner of the earth."

Apparently, then, the millions of extinct species do not count. They are here to be cast aside—and then later to be called in to hold before the eyes of him who would call Nature not aimless, not wasteful, but intent upon life and man.

The man of common sense might, however, summon up enough courage even to ask—most timidly—the great Gods of Authority: "I thought you said living things were so highly adaptable; and yet your colleagues, the paleontologists, claim that there are more extinct species than there are species alive today. Is this a paradox, or am I merely stupid when it comes to logic?"

There is no way, however, of escaping this fact:

Under the most favorable conditions for life to be met with anywhere in the universe, millions of species have become extinct. Why should we say that life is so marvelously adaptable?

And there are numerous corners of the earth which are not teeming with life; and millions of forms found only in isolated regions. The distribution of life is alone as important an argument against the idea of a great capacity for adaptation on the part of life as it is for the idea of evolution.

Further, life is a complex of certain elements and no others, reacting under the influence of certain conditions of energy, and no others. Its environment, really a part of life, is necessarily as intricate as life itself. One would be tempted to say: Only upon a duplicate of the earth can life exist. And then there would not be an infinity of forms inhabiting every corner of the duplicate, but a marvelous variety of forms inhabiting a fair portion of the surface, and having a very spotty distribution; the majority of these forms being essential threads in that dynamic web which alone permits of the development of man.

I also question the statement that life forms are anywhere near to being as varied as those who are taken in by superficialities, like to believe. Is there any form of life which is not constituted of the basic biocomplex of elements—of course with five or six other bio-elements co-operating? Is this diversity? There is only *one* fundamental type of protoplasm.

Biology is more at sea than it should be when it comes to a philosophical outlook, because, above all, it has failed to grasp the deepest meaning of comparative physiology and comparative biochemistry. With superficial differences, the life processes among animals are the same the world over, and the life processes among plants are the same the world over. Where, again, is the infinite variety that is life? The true infinite variety that is life is to be discovered in the multitude of factors responsible for the development and maintenance of one fundamental type of living thing: the protoplasm based upon nine specific elements, themselves parts—absolutely essential parts—of an environment which secretes that protoplasm. Those who have held to the idea that the whole world is alive have just missed the point: man, life, and the entirety of the cosmos are an indivisible unit, though an ever-changing one.

One of authorities says:

"Viewed from the strictly material standpoint, the utter insignificance of life would seem to go far towards dispelling any idea that it forms a special interest of the Great Architect of the Universe." *

* Jeans.

At such outlandish thoughts as mine, our scientists would hold up their arms in agnostic horror, and gasp, "Why such a man would soon come to the old witch-like woman's intuition, that the moon had influence on life!"

And so, like unto those of the old woman, my suggestions are: that without the moon there would be no tides like unto those the earth has experienced over hundreds of millions of years, for solar tides would be nowhere near so great; that without these tides many a strange phenomenon of erosion, tidal bore, brackish water, mangrove swamp, and deep-inland wave-gnawing, there would not have been, to sum their effects—however minor-seeming to the unimaginative—to sum their effects into a total which could not be subtracted from our earth's history and we be here. The moon means tides in the earth's crust, too, as well as in its hydrosphere, and these have played their part in the rise and fall of continents—perhaps only thus was that final straw added to an Atlantis ere it would sink into the deeps, and thereby cause the groaning, quaking sea-bottom, a thousand miles thence, to be spewed up into ranges now eroded into fit habitations of men.

Iodine is the least widely distributed of the life elements, and without it the thyroid swells, the metabolism is slowed, and extinction awaits. But the sea is fairly rich in iodine—as compared to land. And the moon-induced tides slide inland, up the rivers, up the creeks, through the flat swamplands, returning what the rain had borrowed so long before. The waves, greater for the effect of the moon-tugged tides, dash against the rocks, foaming out their energy, but with the foam there fly precious molecules of iodine salts into the air, are later wind-brushed far inland, fall into the soil, are taken up by plants and these last are men's, and men's cattle's, foods. Why was iodine not far from the sea and ready for man? It was once, but in the early days, rain came and washed it away. Why was it not to stay inland? The ancient web of life would have been different, and thus the present web also.

In short, take any property of the materials and forces which make the environment for life. Trace out the interrelations of this property through all their ramifications. Extend the study, even as it ever broadens, far into the past. Then suggest any alteration in this property. Start once more, this time in the far past, and trace all the effects of this alteration upon the history of the environment—and, if you can, of its secretion, life. You will find that there would have been an environmental history, but no history of living things. That minutest variation in the minutest property of any form of matter or type of energy, would, acting through a long period, so gigantically transform life's essential setting that the rise of life would be impossible.

For example, suppose there were more "heavy hydrogen" (an isotope of hydrogen) in proportion to "light hydrogen." Not only does the "heavy water" formed from this "heavy hydrogen" take on toxicity, but the viscosity of this water is 23% greater, and other properties are changed correspondingly. The earth would have been far different—and barren of life—had there been more "heavy hydrogen" in earth evolution. And the distinction between two isotopes of the same element is the most minute distinction, between any two forms of matter, known to physical chemists.

Therefore, it should be evident that those who speak of the adaptability of life have become fascinated by the past history of life, and have not really considered more than very superficially how else it could have been. It is easy to suggest that life could adapt itself to this or that altered influence, but it is impossible to show how the suggestion could be rendered real. Not only would the new property of the environment directly affect the organism chosen as the specimen, but it would also change every other organism in inconceivable, and inconceivably many, ways and induce a major metamorphosis of the environment as a whole. The web of life—constituted not alone of living beings but of the non-living components too—is a cosmic phenomenon. The unthinkable expanse of space-time, the desolate emptiness spattered with flaming masses and dark, dying suns; the island universes, the star clusters, our sun, the other eight planets, the moon, the earth, the atmosphere, the hydrosphere, the lithosphere, and all that in them is, even down the iron and nickel at our globe's core, and the invisible but omnipresent vibrations of energy—all these are part of life's web.

Must one take seriously the objection to our portrayal of the delicacy of life, after all, and say that had things been otherwise, life would have adjusted itself?

Other Factors. Life is even more a delicate balance of phenomena than we have thus far pictured. There are, in all space, only ninety-two elements. Of these only twenty can engage directly in metabolism, and only nine of the ninety-two can form the sole basis for the whole of animate existence. Furthermore, as we have seen, these twenty must take part in the environmental activities essential to the organic web. They must lie at the crust of the earth in specific combination, so as to be available not only to life but also to the cruder play of inorganic phenomena of precisely the right sort. The sun must have them, and at a specific temperature, at the solar surface and in the great solar depths. And the sun must have them in the appropriate proportions. Hence, the material conditions definitely essential to animate nature are beyond all conception narrowly delimited.

The tidal influences of the sun and the planets, as well as the moon, must not exert, through the ages, anything but precisely the right distorting influences upon the earth's crust. Else geological history would be different.

The color of the surface rocks of the earth must be such as to absorb, eon in and eon out, the correct quantities of heat, and reflect away the unneeded, harmful excess.

The variations in the density of the rocks upon the surface of the earth must affect appropriately mountain-masses, rate of erosion, rain-fall, and rain-distribution.

And a host of other considerations are to be of just the right order of magnitude or quality: the earth's size, mass, shape, average density, elasticity, magnetism, electrical and thermal conductivity, and internal structure; the steadiness and rate of the earth's rotation and of its revolution; the inclination of its axis; its distance from the sun; the variations in this distance; its distances from the planets, and the variations in these distances; the slight wobble of the earth in its orbit. "Viewed from the strictly material standpoint, the utter significance of life would seem to go far toward dispelling any idea that it does not form a special interest of the Great Architect of the Universe."

The Organic Portion of The Web

Man is the highest form of life. The microbe is the lowest. How would man fare without the microbe?

All flesh is grass. The grass is the offspring of the soil. The soil, the plant, and the microbe are intimately related.

Weathering of rock by temperature changes involves the opening of seams in the rock; by water involves solution of salts, and cracking; by mosses, lichens, and micro-organisms involves solution and absorption of soluble constituents of the rock, and further cracking by the in-creep of rootlets and then roots. Rock fragments drop and give a foothold for larger plants—but the rock fragments must be mixed with decaying organic matter. The living and dead mosses and lichens are attacked by the microbes which aid in the formation of the humus—the decay is the activity of the microbes. These tiny organisms assist in the first formation of utilizable soil.

Animals and plants contain inorganic substances and carbon and nitrogen compounds. If bacterial decomposition, or decay, of these materials did not occur, those elements essential to all living things would soon become unavailable—locked in the dead bodies of previously existing living things. Life would disappear from the earth.

And the microbes bring about the necessary cycles of the elements in nature—carbon cycles, nitrogen cycles, and cycles of phosphorus, potassium, iron,—of all the life elements.

Microbes also affect the texture, degree of acidity; the moisture absorbing and holding properties; and the availability of the bioelements—of the soil.

Man is, in a major way, the effluence of the microbe.

And what of the microbe—is it capable of existing for a lengthy period without the presence of other forms? Few microbes are not bound up with the remainder of the life web, and those that are not so bound up are doomed to vanish as their limited habitats alter.

The highest form is at the mercy of the lowest, itself at the mercy of countless other protoplasmic variations. It is a secret of nature whether or not man could survive if he disturbed the balance of nature by exterminating even the pestiferous mosquito. Certain it is that man could not annihilate many forms without annihilating himself. The web of organic things is close-knit, and there are few threads hanging loose. And even the loose threads of today were yesterday the main lines of strength in the web. Queerly, the attention of the biological philosopher has been tripped and entrapped not by the giant web proper but by the loose-hanging threads.

CHAPTER IX

The Dignity of Man

HIGHEST of all creatures on earth, has man no peer anywhere in this stupendous universe? There is steadily growing evidence that the advent of man upon this little planet is by far the most extraordinary phenomenon in all creation.

It is true that recent spectroscopic investigations of the light of the stars, including the sun—our own star—and of the moon and the planets, make us more certain than ever of the earth's being a typical sample of cosmic matter, at least as regards a crude supply of the chemical elements. Thus, so far as the chemical elements necessary for life are concerned, living things and perhaps man-like forms or even superior beings could conceivably exist here and there throughout the universe.

It is true that astronomers are almost daily discovering new suns. And as their theories in vogue now run, apparently the greater the number of stars, the greater the probability of there being many solar systems having planets which are possible abodes of life—although of course the group to which the earth belongs is still, and seems likely long to remain, the only known planetary system.

And, finally, it is true that the latest verdict regarding the chances for life on Mars is, in the words of Professor Henry Norris Russell:

"All the necessary and important conditions favorable to life appear to be present on the surface of Mars: an adequate temperature, sunlight, water, atmospheric oxygen, a land surface, days, and seasons. The force of gravity at the surface, and the atmospheric density, though less than those to which terrestrial life is adapted, appear to be well within the limits of possible adaptation." *

Yet, in view of what has been in the previous chapters adduced regarding the delicacy and intricacy of life, the problem boils down to this: Is there anywhere in the universe a planet, the duplicate of the earth?

Why a Planet?

Life Is Possible Only On A Planet. Protoplasm is an organization of certain forms of matter held together by and functioning through the use of certain types of energy. Since life is an organization, it cannot exist where the instability of the environment is so great as to cause

* The consensus of opinion concerning the possible existence of life on Venus, the only other likely planet, is that Venus is far less a favorable life abode than Mars. (H. N. Russell in *Human Biology and Racial Welfare.* By permission of Paul B. Hoeber, Inc., publishers.

the immediate destruction of any conceivable type of structure. The flaming suns which spangle the heavens are therefore scenes desolate of all animate existence. Their particles are too violently active.

At the opposite extreme lie celestial objects where movement, plasticity, and change are reduced to a minimum—where matter exists only in the solid state. Liquid and gas are both absent, and life must be lacking also. Fluids alone can provide the mobile media essential to the production and functioning of protoplasm. So life is impossible on dead stars—suns which once were hot, but now are frozen throughout, and as cold as the deathly chill of outer space, having radiated away the largest portion of their energy.

In nebulas and comets the particles are much too thinly scattered to permit of anything approaching the organization of living material. Bodies of small size, like asteroids, lesser planets, and moons of the order of ours do not exert sufficient gravitational pull either to hold an atmosphere or to prevent the evaporation of liquids and their subsequent total loss. Hence we have left for consideration, so far as regards the possibility for life, only one class of bodies other than planets. There are the dark stars, which may not be all dead stars, but slowly dying suns, still warmed by internal radioactivity and of large enough size to retain an atmosphere and oceans. Here we have at least the important surroundings for life: an atmosphere which could be like our air, seas whose composition could be similar to that of earthly seas, and warmth. It is even possible to imagine surface flames fed from the eon-lasting stores of thermal energy deep within—gigantic volcanoes, perhaps, furnishing the light so vital to the protoplasm we know. Because of its size, a dying star must remain for billions of years at a temperature favorable to life. (Lesser bodies would much more rapidly lose their heat and there would not be enough time for life's development.) So life would have at hand those environmental factors which every schoolboy learns life needs: heat, moisture, light, oxygen, and possibly even simple nutrients—hence why not life?

But the gravitational pull of an average-sized star is tremendous. Gases could well be emitted from volcanic fissures, but only to be liquefied almost immediately. In other words, the pressure upon the gas would be many times the earthly atmospheric pressure. The dark star would be enclosed in a shell of liquid air, even though the temperature were moderate. The enormous pressure would prevent the formation of any protoplasmic structure characteristic of our planet, and would so adversely affect each and every biochemical reaction that all vital processes would be disrupted before they were well begun. Many other factors, in the last analysis just as unfavorable to life would also be operative: the destructive effect of an excess of radioactivity, the greatly increased density of water, the altered rates of diffusion and molecular motion, etc. We have excellent reason, then, to be sure that protoplasm can be found nowhere except upon a planet.

The Earth is Unique

Until late in the last century, it seemed likely that solar systems with earth-like planets are widespread throughout the universe. For, almost up to 1900, the nebular hypothesis was the accepted explanation of the origin of planetary systems. Nebulae are numerous, and according to this hypothesis, every nebula passes through a series of changes which result in the production of a sun with encircling lesser bodies.

Thus, it was believed, the nebula which gave rise to our sun and planets was a mass of widely diffused gas or very fine dust. Probably this immense cloud was at first cold. The tiny particles attracted one another, and this attraction was greatest toward the center of the mass, where the most particles were. Hence, the outlying particles were pulled in toward the center. The cloud assumed a globular shape, and began to rotate. As the giant globe rotated, it became hotter. It grew ever smaller, and therefore spun ever more rapidly. The high velocity with which it rotated caused a flattening of the poles and an equatorial bulge. At last, so great was the speed of rotation, that the central attraction could no longer hold back matter at the equator, and there a ring of gas, or perhaps a ball of the nebular material, escaped. The original mass rotated still more swiftly, and as it did so, rings or balls were successively thrown off. These rings and balls finally condensed to give rise to the planets. In some cases the planets rotated rapidly enough to throw off, in their turn, rings or balls which became satellites. The core of the nebula condensed to produce the sun.

This, in brief, is the nebular hypothesis, which pictures each of the thousands of nebulae as embryonic planetary systems and possibly life-producing worlds. Each of the trillions of stars, then, might well be a sun with attendant planets. A very neat theory and fine-appearing—but it did not fit the facts.

There was one phenomenon in particular which this hypothesis could not explain, and which ultimately caused its downfall. The planets together make up only

1/700th of the mass of the system, but have more than 98% of the momentum of rotation. That is, a very small fraction of the material of the original nebula has almost the whole momentum of rotation.

There is apparently only one way of explaining this fact. There must have been some outside influence which gave sufficient twist to the matter which formed the planets, in order for them to have so much angular momentum as compared to the far more massive sun. The only possible external influence is a passing star.

The Chamberlin-Moulton theory,* which in recent times has completely replaced the old nebular hypothesis, is based upon the necessary assumption of the approach of two stars, one of them the sun. Thus it provides for the requisite outside influence.

The Chamberlin-Moulton theory states, as does the nebular hypothesis, that the sun, like all stars, arose from the condensing gaseous material of a nebula; but without external influence our sun would be merely another star, and entirely without offspring.

Therefore it must have been that a large star once passed near the sun, and because of the force of gravitation raised such enormous tides in the solar atmosphere that the sun's surface was torn apart. A considerable

* Now the Chamberlin-Moulton-Jeans-Jeffreys theory.

portion of the gas making up the sun was poured out into space. Probably most of this material was pulled by gravitation back into the sun. Some of it, however, was given sufficient crosswise motion by the gravitational influence of the passing star to make it wheel in elliptical paths around the sun. Gradually these paths (of the various portions of the ejected material) became more circular, and now are the orbits of the planets.

So, today astronomers no longer regard every point of light in the sky as a center around which revolves a possible home for life. For, according to this theory, planets must be very rare indeed, since they arise only when two stars (1) come exceedingly close to one another, or (2) barely graze one another, or (3) actually collide. And stars are so far apart that in 1,000,000,000 years there is only one chance in 1,800 that one star will come near enough to another to bring about the ejection of matter and the formation of planets. According to the most recent estimates, the maximum number of stars which can have planets is one in every 100,000.

Nevertheless, this means that, for every trillion stars, there are possibly 10,000,000 solar systems. Therefore, with many trillions of stars in the heavens, there is a possibility (seemingly) for many times ten million solar systems. Finally, where there may be so many solar systems, it would seem likely that we must find in this great number, at least a few duplicates or near duplicates of the earth.

On the other hand, this figure of a possible maximum of one solar system among every one hundred thousand stars is well worth re-examining. Certainly we are entitled to enquire the bases upon which this result is calculated. The velocities with which the stars move through the heavens are known (approximately), as are also the distances between the stars. The average size of the stars has been determined within what are probably very narrow limits of error. Hence, it is a fairly simple mathematical problem to find out what the chances are of a close approach of two stars—a close enough approach to bring about disrupting tidal influences upon at least one of the stars. It is upon these bases that the maximum of one planetary system for every one hundred thousand stars was reached. One highly important consideration, however, was neglected. Mere proximity in space would not necessarily mean the production of a solar system; or, if a solar system were produced, that solar system would not necessarily be at all like the one which we inhabit.

Stars would not approach one another at the same angle or at the same rate—the rate used in calculating the probability of a close approach is the estimated average velocity. For, two stars might be travelling almost in the same direction; or they might collide head on; or they might approach at any other angle whatsoever. If the angle of approach differed by the tiniest fraction of a degree from the angle of approach of our sun and the star which billions of years ago passed close by it, then an entirely different planetary system would be formed, if one were formed at all. Thus, not only the chances for the origin of solar systems in general, but also the chances for a system similar to ours are greatly reduced.

Our sun is often spoken of as an "average" star. But stars differ not merely with respect to velocity, direction, and position, but also as regards many other characteristics: size, chemical constitution, temperature (surface and internal), density, density-variation throughout, electromagnetic attributes, temporary and permanent nature of surface and internal spheres, and numerous other characteristics which for the sake of brevity may be grouped under the general heading of age and life history previous to the approximation.

In other words, even a most superficial analysis of the effects of a variation in any one of a lengthy list of highly important qualities brings out clearly the still smaller likelihood of the production of a group of planets similar in the least fashion to those of our sun. It cannot be too strongly emphasized that this line of argument, when carried out to its logical conclusion, would show that even in view of the vast number of stars, there is nowhere in the universe a planet like the earth. No planet would duplicate the earth unless precisely like the earth in size, form, superficial and internal conditions, density, chemical constitution, distance from the sun, and its possession of a mother sun precisely like the one of earth's, of a moon exactly like earth's moon, of the same tilt of axis, of a like orbit and orbit-wobble, and of an identical set of relationships to eight other planets, each one of a type probably unique.

It might seem absurd to suggest that earth's position in the universe makes a difference. But the cosmic rays prove to us that all portions of our cosmos are not alike. And the astronomer-mystifying fact, that more meteorites fall during one half of the day than fall during the other half-day, is evidence to the same effect. And the majestic sweep of the nebulae, island universes, and star clusters, millions of light-years away, are not without their gravitational pulls upon the symmetry of our smooth-cycling planetary system.

The evidence, such as there is of it, is that earth and earth-man are unique. And we may look hopefully for new support for this belief. Did not the collapse of the nebular hypothesis bring the encounter theory, and much less opportunity, so far as human knowledge goes, of there being other planetary systems beyond ours? And is not the encounter theory already wrecked upon the mysterious peculiarities incident to the development of our sun-gripped nine globes and their attendant moons? * It is more difficult to form a system of the order of ours than astrophysicists once thought. Perhaps ours is after all the only one. At any rate man is unique.

The Thirteen Objections

The First. Man has imperfections. But, as we have seen, man's brain-mind is infinity reborn. The imperfections when placed beside the human potentiality are like infinitesimals alongside the infinite.

The eye may not be mechanically perfect. But did not Milton, blind, see infinity?

The appendix is useless—now. It is a souvenir of the days when it must have *been,* or man as we know him

* The Chamberlin-Moulton theory does not successfully account for the retrograde motions of certain satellites of the outer planets or for the excessive density and excessive massiveness of our own moon. Moreover, additional difficulties have been discovered in this theory, so that one could justifiably state that astronomers simply do not know how our planetary system was formed. And the newer suggestions range from phenomena like an actual collision, head-on, between two suns, to phenomena like the flaring up (explosion) of a nova.

now, not have evolved. The appendix was part and parcel of an ancient, necessary web of life. Today's web is an effluence of that old one.

Further, the appendix is useless—but beside the useful brain, what matters an insignificant waste?

The Second. Man's environment is dangerous; man may die. Why not use the brain more? No one can deny that man is still here, unless it be the mystic, himself a man, who does the denying.

The Third. If Nature were intent on making man, Nature were wasteful. Still, man is here, and the waste was a part of the process and a required part, not waste —except to those who say, Do not anthropomorphize— and then say, Nature is *wasteful.* Beside man, if indeed it were waste, the waste is another infinitesimal beside the significant infinite.

The Fourth. Nature's mind—mind you it is a teleophobic anti-anthropomorphist who speaks this objection—Nature's mind has wandered aimlessly as it would not have had she been intent on yielding man. First, if it has been aimlessness, that aimlessness, however large-looming in the dark of ignorance, thins to transparency in the light of a full understanding of human dignity. Some say Nature must have been a genius to produce such a freak as man—the anthropomorphist ought to expect a little wandering on the part of genius; is it not the way of genius?

Second, the millions of extinct forms, apparently irregularities in the stream of life, were definitely part of a larger, necessary regularity—the early web of life: out of this web and no other could we have escaped.

About the dinosaurs:

"It is easy to anthropomorphize, to invest the dinosaurs with our feelings and our spiritual questionings. Could they not think as they roamed the earth and perceived themselves the dominant beings, the kings of creation, or did they know dimly their long history and think of themselves as of yesterday, today, and tomorrow? Could they not think of themselves as the summit of life, and truly the emperors for all time ensconced in their pleasant palaces? So may wonder those who invest them with mind.

"But the evil day dawned, and we may think upon the last dinosaur, silent upon the peak of the Cretaceous, straining his eyes to penetrate the mist of the infinite future. What glimpses he could have had! Lands flowing with milk and honey, glorious chances to be taken and rich harvests to be obtained, and the only competitors but puny things compared to him. But strain as he might he would have seen none of his fellows in that glorious future. And when he died there was no great change or mourning in the universe. The birds may still have sung, the mammals rustled and squeaked in the undergrowth, the sun shone by day and the moon by night, and the pleasant streams tumbled and sparkled to the cool and shady pools. For the clock of Nature ticks interminably and disconcertingly on, as all who stand in the shadow of death must know. Some lie in that shadow, but the rest of nature scuttles by and after a momentary shudder carries on as before, while the stricken, unnoticed, lie dead and rotten and forgotten. . . .

"The career of the dinosaurs was far from brief, and far from a futile or vain attempt to snatch a permanent hold on the chain of life. Their passing was comparable with, and no less dramatic than, that of a mighty empire of world-wide extent. *But that same passing was complete, and gave, no doubt, the all-important stimulus for the development to the hitherto repressed mammals, whose evolution has culminated in Man.*" *

The Fifth. Man may not represent the height of evolution. But as we have seen, no higher beings exist. And there is no evidence whatsoever of the coming evolution of a higher form.

The Sixth. There might be other types of protoplasm potential within elements not now used by life. But, as we saw, life *is* the organization of highly specific types of substances and of forces: more especially of the basic biocomplex of nine elements, usually with one or more other bioelements co-operating. Without these specific elements, there would be no life, for, these elements are unique.

* W. E. Swinton, *The Dinosaurs*, Thomas Murby and Company, London.

The Seventh. Many factors in the cosmic formula do not seem related to man. Yet, upon peering more deeply into the essence of things, we find all factors involved in man's development.

The Eighth. Man is an accident. What is an accident?

The Ninth. Henderson attempted to show that the fitness of the environment is so striking that it is highly improbable for this fitness to be the result of chance. Common sense would agree with Henderson. We dwell beyond the realm of chance, and the fitnesses of the environment for life are such as to convince us that life forms the central theme of a cosmic plan.

The Tenth. All is the play of Fortuity. What is Fortuity but a fiction?

The Eleventh. There is a difficulty involved in choosing a method of calculating the probability of life's being a chance phenomenon. Such considerations do not enter into a camera study of the phenomena of the universe.

The Twelfth. Again, Chance—another aspect. What is Chance? A fiction, sometimes of practical value.

The Thirteenth. If man is no accident, he may be at most a mere incident. We cannot, however, regard man as a mere incident, because all the properties of matter and energy are directly concerned in his origin, endurance, and development. Besides, man is the possessor of infinite capacities, inherent in his mind. Even in an infinite universe, the extent of his ability and promise raise him above insignificance.

CHAPTER X

Science Unknowingly Rediscovers God

AND SO, the universe is "made of stuff which had the potential power to raise itself to self-consciousness" in man. Too, this potential power was not inherent in merely a part of the cosmic stuff but necessarily, because of the very intricacy and delicacy of self-consciousness, the essential nature of every aspect of the patterned stuff, whose *intent,** we see, was through heaped eons, the brain-mind of humans. This is the common-sense understanding of what science has both of old and recently collected in its disorganized, misinterpreted piles.

Yet, while common sense calls metaphysics an organism which is continually swallowing itself and while common sense would assert "There ain't no such critter—really," metaphysics is ever denying the very existence of common sense. Therefore, we must take a brief dive deep into the muddy waters of metaphysics, examine its secret bottom, and hope to swim back to the surface and gain the shore still alive and sane.

* I use the word metaphorically, not anthropomorphically (i. e., in a crude sense).

Common Sense

All reasoning and all judgments and all philosophy ultimately depend upon that which we all must call common sense. Does not every thoughtful individual, at one time or another, pass through a period of doubt? Is there really any logic which can overcome scepticism, once thoroughly aroused? It follows that when a philosopher, or other person, makes a beginning, he has, for no logical reason whatsoever, left doubt behind. Thus, indeed, common sense makes him feel that he has found a starting point. He may be merely bored with so much doubting, or he may pass through some great phase of emotional stress, which phase may be the source of an inspirational beginning. Thus, all logic can be shown to be based upon—or at least to commence with—what is commonly accepted as sensible. Logic alone does not tell you where or when to commence, or where or when to leave off.

Still, what is common sense to one individual, is frequently the rankest imbecility to another. But this is not the important point—nor is it the point at which metaphysicians choose to see the so-called "philosophy of common sense" break down. What is the important point is that we all make a sensible beginning—and the lines along which our thought later runs depends upon our experience, which has been gained before or is gained after our reasoning has been permitted to have a start, or a renewed attempt.

The broader our experience the better our common sense. And the more accurately and efficiently the brain-mind functions, and the more readily it assimilates and integrates what our senses bring to us of the objective world, the better our common sense. Common sense, then, varies, as all characteristics do, from individual to individual. It is scarcely really *common* sense, though there is no better term for it—there is no use seeking a better: the mud of metaphysical stirrings would clog our eyes. If I were to attempt a definition of what I call common sense: It is that capacity of the brain-mind* for accurately reflecting to self-consciousness the dynamic panorama of the objective world, for quickly picking out the details relevant to some general principle (causal relationship) involved, and for so assimilating these details that they are realized to be partial knowledge, though knowledge to be gainfully used in predicting the likelihood of certain future phenomena. And common sense at the same time under-

* A grade of organization of matter and energy, the nature of which organization it is to sense and emotionally to ponder upon its environment and upon itself. Common sense is, then, one aspect of the normal operation of the best-constructed brain-mind.

stands the future phenomena are but particular instances related through some grand relationship to the past and the present—and the functioning of the cosmos as a whole.

More than this I could not swim back with and gain the shore whose firmness alone supports the unstable inseepings and outseepings of the waters of that high fancy—metaphysics.

And therefore I feel that those of us who have attempted fully to grasp the deepest meaning of science's camera studies of the universe, who have ignored the scientist's own philosophizing thereupon, and who believe that logic is not without its common-sense limits—and that the existence of the grandest of architectures means the presence of a Grand Architect, will agree that, in a very concrete way, Science has rediscovered God. And been unaware of it.